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R B Peck

PROCEEDINGS

OF THE

FIFTY-NINTH ANNUAL CONVENTION

OF THE

American Railway Engineering Association

Construction and Maintenance Section, Engineering Division
Association of American Railroads

HELD AT THE

SHERMAN HOTEL, CHICAGO
March 14, 15, and 16, 1960

VOLUME 61

This volume, as listed in the Table of Contents, includes all the committee reports, reports on research projects, monographs, and memoirs originally published in AREA Bulletins 551 to 556, incl., June–July 1959 to February 1960.

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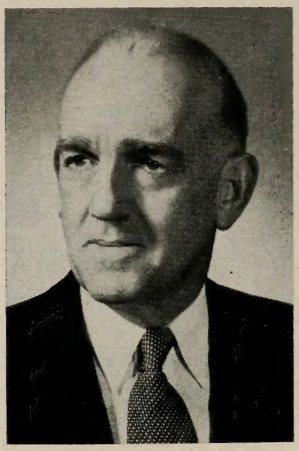

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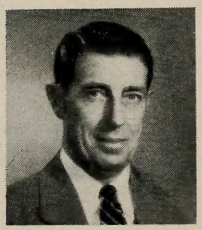

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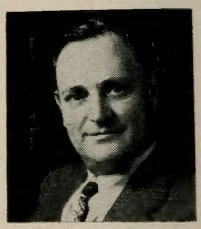

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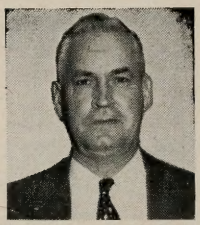

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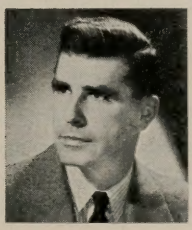

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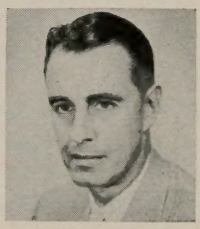

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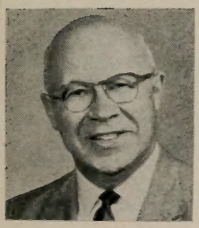

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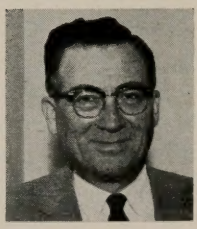

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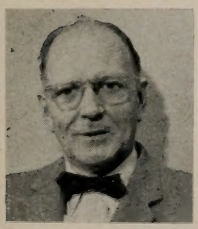

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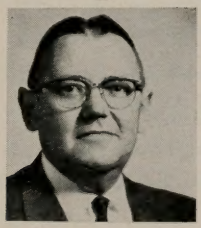

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Advance Report of Committee 3—Ties

Assignment 5

Methods of Retarding the Mechanical Wear of Ties, Including Stabilization of Wood, and the Splitting of Cross and Switch Ties

Collaborating with Committee 5

P. D. Brentlinger (chairman, subcommittee), R. S. Belcher, A. C. Black, R. G. Brohaugh, C. S. Burt, W. J. Burton, G. B. Campbell, C. J. Code, L. C. Collister, T. H. Friedlin, A. K. Frost, W. E. Fuhr, H. E. Grier, F. F. Hornig, B. D. Howe, C. E. Jackman, W. R. Jacobson, H. F. Kanute, R. W. Orr, C. A. Peebles, R. R. Poux, W. C. Reichow, N. B. Roberts, H. S. Ross, C. V. Schutt, E. F. Snyder, L. S. Strohl, S. Thorvaldson.

This is the first progress report on the study of the effectiveness of anti-splitting devices for the reduction of splitting in cross ties which is being carried out at the Association of American Railroads' Research Center. The study is sponsored by Committee 3—Ties, and is being performed and reported on by H. M. Sutcliffe, research technician of the research staff of the Engineering Division, AAR, under the general direction and supervision of G. M. Magee, director of engineering research.

Introduction

Splitting has been one of the major causes of tie failure since the use of treated ties became standard practice. Many kinds of anti-splitting devices have been tried with varying degrees of success. Most railroads use some kind of anti-splitting device to retard end splitting. Flat or crinkled S- or C-irons or spiral dowels are most commonly used. Some railroads have shifted from one type of device to another in an attempt to get improved performance. Others have abandoned the use of anti-splitting devices except to salvage ties which have already split. This varied opinion among tie users led to the request that the Engineering Division of the Research Center undertake a study of the effectiveness of the various anti-splitting devices available.

General Discussion

It has been established by the Forest Products Laboratory of the United States Department of Agriculture at Madison, Wis., that splitting of wood occurs only after the moisture content drops to 30–35 percent, the point at which wood shrinks. The shrinkage tangentially along the annular ring is greater than the shrinkage radially across the rings It is this uneven degree of shrinkage that sets up stresses within the tie which exceed the bonding strength of the wood to cause a split.

In a log or pole the annual rings are full circles which put a fairly uniform stress on the wood within them, resulting primarily in a compressing action. However, when a log is sawed to make a tie, the annular rings are cut, and the sections of annular rings tend to straighten as they shrink because the remainder of the rings is no longer present to balance the shrinkage stress. This action also causes warping in thin boards that do not have edge grain. Timbers of large cross sectional dimensions, such as cross ties, which do not have a square cross section, will usually check or split through the pith (heart) across the narrow dimension. The straightening action caused by the shrinkage of the growth rings applies a stress on each side of the pith, in opposite directions. When this stress becomes greater than the split-resisting strength of the wood, splitting results.

All anti-splitting devices have been designed to resist the splitting forces created by shrinkage of the wood. Until the wood splits sufficiently to offset the shrinkage that caused the split, the device cannot be effective in controlling the split. To be effective an anti-splitting device must have sufficient strength and holding power in the wood to resist any splitting force that might develop and must remain in place throughout most of the life of the tie.

Many flat S- and C-irons loosen or fall completely out of the ties in 5 to 8 years of service in track (Fig. 1). Crinkled irons with ribs do not work loose as readily. Brine from refrigerator cars often corrodes the iron completely in two in 10 to 15 years. Dowels withstand corrosion much better than end irons.

Field Tests

Through the courtesy of cooperating railroads three tests were conducted to determine the effectiveness of dowels, C-irons, incising, and C-irons plus incising in preventing splitting of cross ties during seasoning. In addition, two field tests are in progress in which S-irons and dowels are being compared. Unfortunately, the oldest field test using dowels and S-irons, which was started in 1934, suffered a derailment through one section of test track, and the installation of CTC converted the other test section from double to single track. A tie count has been resumed to determine the tie renewal rate and thus the average life for these ties. It will take several years to accomplish this.

The second field test using S-irons, dowels and control ties was started in 1955 and is not old enough yet to ascertain anything except that considerable splitting occurs after the ties are laid in track. Less than 50 percent of any of the test groups had no splits at all. At this time no pronounced difference in splitting between control, S-ironed, or doweled ties can be seen.

Seasoning Tests

The first seasoning test compared the effectiveness of C-irons and dowels in preventing splitting of cross ties. In this test 13,558 oak ties, mostly from Kentucky and Tennessee, were used. Just prior to treatment, these ties were inspected and graded as follows: no split or check, no split but acceptable check, two-face split less than 5 in, three-face split less than 5 in, four-face split less than 5 in, all of which were acceptable, and rejects for season check or split. The results are given in Table 1. Doweled ties had the fewest rejects for any kind of splitting, averaging 6.6* rejects. The average for C-ironed ties was 9.7. Control ties had 13.8 rejects.

In the second seasoning test, controls, C-irons, incising, and C-irons plus incising were compared. All these ties were from one shipment of oak ties cut in Mississippi. As a group these ties split much worse than the first seasoning test (Table 2). In the control group of the second test, 24.5 ties were rejected for some sort of splitting as compared with the average of 13.8 rejects in the first test. In the C-iron group there were 15.8 rejects compared with the average of 9.7 in the first test.

This shows how variation in the quality of wood can affect splitting, as both tests were seasoned in the same yard at the same time. However, all Mississippi ties did not have this high splitting rate. In the first test there were some C-ironed ties from Mississippi which had a reject rate of only 6.2 per hundred acceptable ties. Similar ties in the second test had 15.8 rejects.

* Expressed as the number of rejects per 100 acceptable ties.

C-irons plus incising, with 11.5 rejects, performed best in this group. There was only a small difference in rejects between C-irons and incising by themselves—15.8 for C-irons and 17.1 for incising. All were better than the 24.5 rejects for control ties.

Laboratory Tests of Holding Power

To determine the holding power of the various anti-splitting devices, 8 green ties were cut into 22-in sections after cutting approximately 8 in from each tie end to have as uniformly green sections as possible. These short sections were ripped along the 9-in face into two matching pieces, each 4½ by 7 by 22 in. Countersunk bolt holes were drilled to accommodate a T-shaped pull bar to be located at the center of the specimen. One-half inch bolts, with large washers to distribute the load over a large area, were inserted into the holes, and the two matching halves of the tie section were banded tightly together. The anti-splitting devices were then applied to each end, after which the bands around the tie were removed.

Holding-power tests were made in triplicate in both green and seasoned wood, except that 6-in stronghold nails, gang nails, and single S-irons were tested in green wood only. Green tests were made immediately after the irons had been applied. Seasoned tests were made after drying for three months indoors where the temperature remained fairly constant at about 75 F.

Dowels had greater holding power than any of the other devices (Table 4). Too, they were the only ones to gain holding power on seasoning, showing more than a 25-percent increase. Three-flute dowels held a little better than four-flute dowels. Both S- and C-crinkled-irons had slightly greater holding power in green wood than flat C- and S-irons, but had much greater holding power in seasoned wood. However, both flat and crinkled irons lost strength on seasoning. The crinkled irons lost about 10 percent on seasoning while flat irons lost 30 to 50 percent of their holding power. S-irons had slightly lower holding power than C-irons, but not enough to be significant. Eight-inch stronghold nails were about equal to flat S-irons in both green and seasoned wood. Six-inch stronghold nails were weaker. Only one gang-nail test was made because of the difficulty encountered in applying them. A hydraulic press was used, but the points of the nails would bend if the surface of the tie was at all rough. In this single pull test the gang-nail device had as high holding power as in the best individual dowel pull test. Failure occurred when the nails sheared from the plate.

The results obtained in these tests correlated closely with those obtained by the Erie Railroad in 1938 and by the Pennsylvania Railroad Company in 1947. Further testing was done in which S-irons and dowels were imbedded in the wood at various depths up to one-half the length of the device. The portion of the device which protruded from the wood was clamped directly into the test machine to make the pull test. This was the same procedure followed by the two railroads. In this manner the holding power of the device at various depths of imbedment was measured. Ties at various stages of processing and service life were used in these tests, as shown in Table 5. The pattern of dowels having greater holding power than S-irons was repeated, although the difference here was not quite as great as for the tests reported in Table 4.

After nine years of service a few of the S-irons were badly corroded. Dowels did not suffer as much from corrosion. This correlates with tests on crinkled Sharon-irons and dowels after 11 years of service on the Pennsylvania Railroad. About half of the Sharon-irons had corroded sufficiently to have little or no holding power. Some had corroded completely in two. The average holding power was approximately 600 lb per in of iron imbedment for the remaining irons. The dowels averaged 1150 lb per in

imbedment. A few showed some loss in holding power due to weakening of the wood by reaction with the iron rust.

Accelerated Seasoning

Accelerated seasoning tests were conducted inside the laboratory where the temperature remained fairly constant at about 75 F, usually going higher than that during the day in the summer. Green ties were cut in half. One-half had anti-splitting devices applied and the other half was left as control. Knots were avoided in the area of the cut as much as possible. Thus the iron was applied to the tie before any drying occurred and had a mating section as a control.

This study was not confined to the use of anti-splitting devices alone. Saw kerfs, or cuts, were made in the ends of several ties in various patterns in an effort to relieve the stress which builds up in the tie as it shrinks, rather than to try to restrain the stresses as is done with irons and other devices. Accelerated seasoning was conducted on ties with the following anti-splitting devices, saw kerfs, and combinations of the two:

Single S-irons, flat.

Double S-irons, flat.

Double S-irons, crinkled.

Double C-irons, flat.

Double C-irons, crinkled.

Three-flute dowels, 3 in from the end, 1½ in from each 9-in face.

Three-flute dowels, 6 in from the end, 1½ in from each 9-in face.

Four-flute dowels, 3 in from the end, 1½ in from each 9-in face.

Four-flute dowels, 6 in from the end, 1½ in from each 9-in face.
Six by 8-in gang nails.

Six-inch stronghold nails, 3 in from the end on each 7-in side, ½ in from each 9-in face.

Eight-inch stronghold nails, 3 in from the end on one 7-in side, 1½ in from each 9-in face.

One-half inch machine bolts with washers, 6 in from each end, 1½ in from each 9-in face.

Squared "O" irons.

Double Beegle irons.

Three horizontal saw kerfs on each 7-in side, 2 in deep at the end, tapering to nothing 16 in back.

Three horizontal saw kerfs as above, plus double 4-in C-irons.

Two vertical saw kerfs of equal spacing across the ends, 2 in deep.

Three vertical saw kerfs of equal spacing across the ends, 12 in deep.

One vertical saw kerf in the center of the end, 12 in deep.

Three vertical saw kerfs in the 7-in sides, 2 in, 1½ in, and 1 in deep at 5 in spacing apart and from the end.

Three vertical saw kerfs as above, plus double 4-in C-irons.

TECO saw kerf in the end, parallel to and 1½ in from each 7-in side and 9-in face, 2 in deep.

The ties having saw kerfs 12 in deep were seasoned 8 months and the others for 12 months. Some have split badly, others have split very little even on the control section of the tie. No comparison between ties was possible because of the widely

varying degree of splitting on the control ties. Only a slight retarding of splitting was noted for any of the anti-splitting devices. Some of the saw kerfs appeared to have helped reduce the splitting action.

Stress Measurement

In an attempt to measure the splitting forces within the wood which are brought to bear on the anti-splitting devices, strain gages were installed on four-flute dowels, flat C-irons and flat S-irons. One strain gage was mounted on each side of the iron near the center. Flat sections about 5/16 in wide and 1¼ in long had to be milled in the spiral dowel in order to mount the strain gages. An axial hole ⅛ in. in diameter was drilled from the driving end of the dowel to the flat section where the strain gage was located. This provided a means for bringing the wire leads out. Two dowels were driven into the 7-in face of the tie 1⅞ in from the 9-in faces and 3 in from the end for one tie and 6 in from the end for another. To drive the S and C-irons without disturbing the strain gages, a short section of the end of the tie was routed out ⅜ in wide and 1½ in deep where the gage position on the iron would come when the iron was driven. The electrical leads were thus exposed. Single S-irons, double S-irons and double C-irons were used in the test.

Readings were taken daily at first, then less frequently as the ties seasoned until weekly readings were being taken. The test was started February 21, 1958. In each case, except for the single S-irons, the irons first went into compression before going into tension, indicating the shrinkage which took place before sufficient splitting occurred to place the irons in tension. (Fig. 3 shows the stress development in C-irons which was typical for all the devices tested.)

The tension load on both the dowels and the C- and S-irons was much less than the holding power of the devices. The maximum tension load developed in the S- or C-irons was less than 250 lb on the portion of the iron in the vicinity of the strain gage. The maximum tension load on the dowels was 1400 lb for those driven 6 in from the end and 700 lb for those driven 3 in from the end.

Discussion of Results

The extent of the splitting which occurs during seasoning apparently depends as much on the kind of weather during the seasoning period as on the type of anti-splitting device used. Anti-splitting devices do not prevent splits, they merely reduce the number and degree of splitting. Further study will be needed to determine how much protection these devices give in track service.

To make out-of-face application of anti-splitting devices profitable, the ties which benefit must increase the average life of the group sufficiently to cover the cost of applying the devices to all the ties. Thus, for a main line tie costing $7.00 in track and which has an average life of 30 years, the annual cost of the tie is $0.40, based on 4-percent compound interest and using the AREA formula for calculating tie costs. At $0.20 per tie for the cost of C- or S-irons, increasing the average life of the group two years would pay for applying the devices out-of-face. At $0.40 per tie for the cost of dowels, an increase in life of four years would be required.

Since splitting occurs during seasoning in many of the ties to which devices have been applied, better protection might be afforded by application of the devices after seasoning. To do this it would probably be necessary to squeeze the ends of the ties together before the device would be applied. This would probably increase the cost of application. By applying anti-splitting devices only to those ties which have split or started to split, it might be possible to reduce the over-all cost through the reduction

in number of ties to which devices would be applied. Doweling and banding should offer the most promise here. One field test covering selective doweling has been started and another is contemplated.

Saw kerfs cut into the ends of the tie before seasoning appear to have promise for reducing the splitting which occurs during seasoning. No information is available on what effect heavy traffic would have on developing splits at the saw kerfs. A field test would be necessary to determine how effective kerfing would be.

Crinkled C- and S-irons with a rib hold better and stay in the tie better than flat irons or crinkled irons without a rib. The very small additional cost appears to be quite worthwhile.

Field tests which are in progress include comparisons of:

1. Application of devices to green and to seasoned ties.
2. Out-of-face application of devices with selective application.
3. The effectiveness of S-irons, C-irons and dowels.

TABLE 1

EFFECT OF C-IRONS AND DOWELS ON SPLITTING OF CROSS TIES DURING SEASONING

Treat Plant	Production Source	Number Ties Inspected	Acceptable Ties: No Split	2-Face Split	3-Face Split	4-Face Split	Rejects
			Control				
1	Kentucky	730	70.8	21.4	6.1	1.7	11.6
2	Tennessee	928	60.0	27.6	9.6	2.8	14.7
1	Kentucky-Tennessee	2145	61.3	31.3	6.5	0.9	14.2
	Average		64.0	26.8	7.4	1.8	13.8
			C-Irons				
1	Kentucky	1490	60.2	33.6	5.4	0.8	9.8
2	Tennessee	1058	56.6	36.4	6.9	1.1	12.1
1	Kentucky-Tennessee	1515	70.5	27.3	2.6	0.6	10.8
2	Mississippi	1133	62.9	28.8	6.3	2.0	6.2
	Average		62.6	32.0	5.3	1.1	9.7
			Dowels				
1	Kentucky	1544	62.9	24.5	9.7	2.9	3.3
2	Tennessee	1030	48.4	39.7	8.7	3.2	11.6
2	Mississippi	1124	56.6	30.6	9.4	3.4	4.8
	Average		56.0	31.6	9.2	3.2	6.6

(All values in Tables 1, 2 and 3, except the number of ties inspected, represent the number in each classified group per 100 acceptable ties.)

TABLE 2

EFFECT OF C-IRONS AND INCISING ON SPLITTING OF OAK CROSS TIES DURING SEASONING

Type of Protection	Number Ties Inspected	Acceptable Ties Under 1/8"	1/8"-1/4"	1/4"-1/2"	Over 1/2"	Split Rejects
Control	325	14.6	37.1	38.7	9.6	24.5
C-Iron	205	20.9	18.1	44.1	16.9	15.8
Incising	711	6.1	42.8	43.9	7.2	17.1
C-Iron and Incising	676	8.7	34.3	48.9	8.1	11.5

TABLE 3

VARIATION OF SPLITTING IN OAK CROSS TIES AS STACKED AFTER TEN MONTHS SEASONING

Type of Device	Rick No.	No. Ties Inspected	No Split	Split Acceptable	Split Rejects
C-Irons	80	268	93.6	6.4	0.8
C-Irons	82	268	91.0	9.0	0.0
C-Irons	100	268	83.0	17.0	6.4
Dowels	84	260	78.0	22.0	0.4
Dowels	86	268	76.2	23.8	4.3
Total					
C-Irons		804	89.3	10.7	2.3
Dowels		528	77.2	22.8	2.3

TABLE 4

COMPARATIVE GREEN AND SEASONED HOLDING POWER
OF VARIOUS ANTI-SPLITTING DEVICES

Type Iron	Green Tie No.	Green Pull Lb	Ave. Green Pull Lb	Season Tie No.	Season Pull Lb	Ave. Season Pull Lb	Change Due to Season %	Pull/Inch Imbedment -Lb Green	Pull/Inch Imbedment -Lb Seasoned
3-Flute Dowel	H 1B	17,800		H 8B	26,500				
3-Flute Dowel	H 3A	20,600	20,213	H10A	26,700	25,740	+27.3	1440	1830
3-Flute Dowel	H 5A	22,240		H12A	24,020				
4-Flute Dowel	H 1A	16,200		H 8A	23,850				
4-Flute Dowel	H 3B	18,700	17,550	H10B	22,700	22,617	+28.8	1250	1610
4-Flute Dowel	H 6C	17,750		H13C	21,300				
6" S.H. Nail	H 1C								
6" S.H. Nail	H 3C	6,420	6,035						
6" S.H. Nail	H 6A	5,650							
8" S.H. Nail	H 1D	8,820		H 8C	10,600				
8" S.H. Nail	H 6B	9,600	9,817	H13B	7,800	8,147	-17.0	700	580
8" S.H. Nail	H15D	11,030		H14D	6,040				
Double C-Iron, Flat	H 2A	13,600		H 9A	5,920				
Double C-Iron, Flat	H 4A	11,900	12,500	H11A	5,600	6,147	-50.8	1130	550
Double C-Iron, Flat	H 5C	12,000		H12C	6,920				
Double C-Iron, Crink	H 2C	13,900		H 9C	11,040				
Double C-Iron, Crink	H 4C	12,700	13,033	H11C	12,050	12,043	- 7.6	1180	1190
Double C-Iron, Crink	H 5D	12,500		H12D	13,040				
Double S-Iron, Flat	H 4B	10,900		H 9B	7,230				
Double S-Iron, Flat	H14B	8,840	10,237	H11B	6,500	7,177	-29.8	930	650
Double S-Iron, Flat	H15A	11,000		H14A	7,800				
Double S-Iron, Crink	H 2D	11,800		H 9D	11,100				
Double S-Iron, Crink	H 4D	11,400	12,400	H11D	9,700	10,947	-11.7	1120	990
Double S-Iron, Crink	H15B	14,000		H14C	12,040				
Gang Nails	H 8D	22,000	22,000						
Single S-Iron, Flat	H 3D	4,840							
Single S-Iron, Flat	H 5B	4,900	4,660						
Single S-Iron, Flat	H 6D	4,240							

TABLE 5

HOLDING POWER OF S-IRONS AND DOWELS AT VARIOUS STAGES OF PROCESSING AND SERVICE LIFE

Wood Species Group Classification	Seasoning Period Months	Was Tie Treated	In Track Service Yrs.	Type Iron	Was Iron Applied Before Seasoning	Average Pull/Inch of Iron - Lb
TA	20	No	0	S	Yes	1030
TA	14	No	0	Dowel	Yes	1220
TA	20	Yes	0	S	Yes	1140
White Oak	14	Yes	0	Dowel	Yes	1590
Red Oak	14	Yes	0	Dowel	Yes	1240
TC	6	Yes	9	S	Yes	890
TC	6	Yes	9	Dowel	Yes	1300
Red Oak	20	No	0	S	No	970
Red Oak	20	No	0	Dowel	No	1290
TC	6	Yes	0	S	Yes	860

Fig. 1—End irons loosened in track.

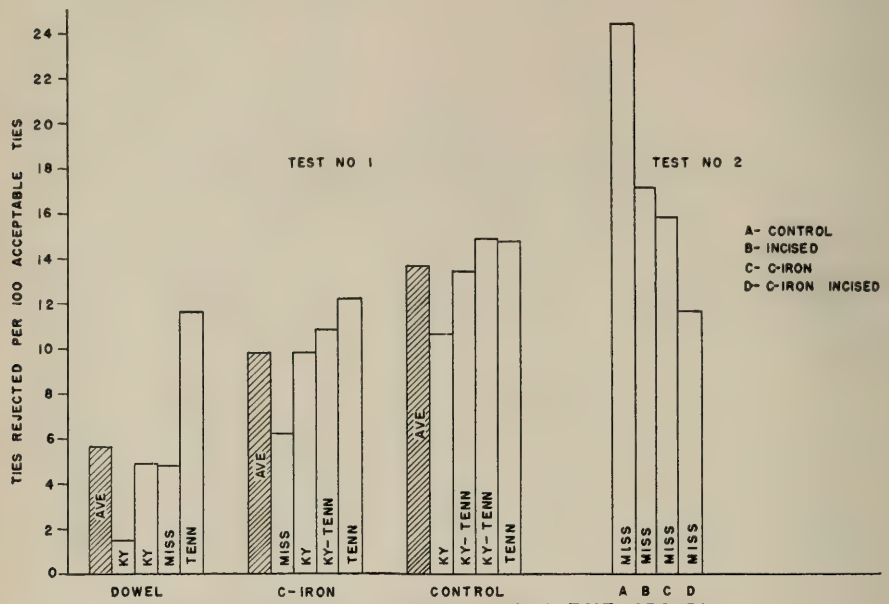

FIG. 2 – VARIATION OF SPLITTING WITHIN TEST GROUPS

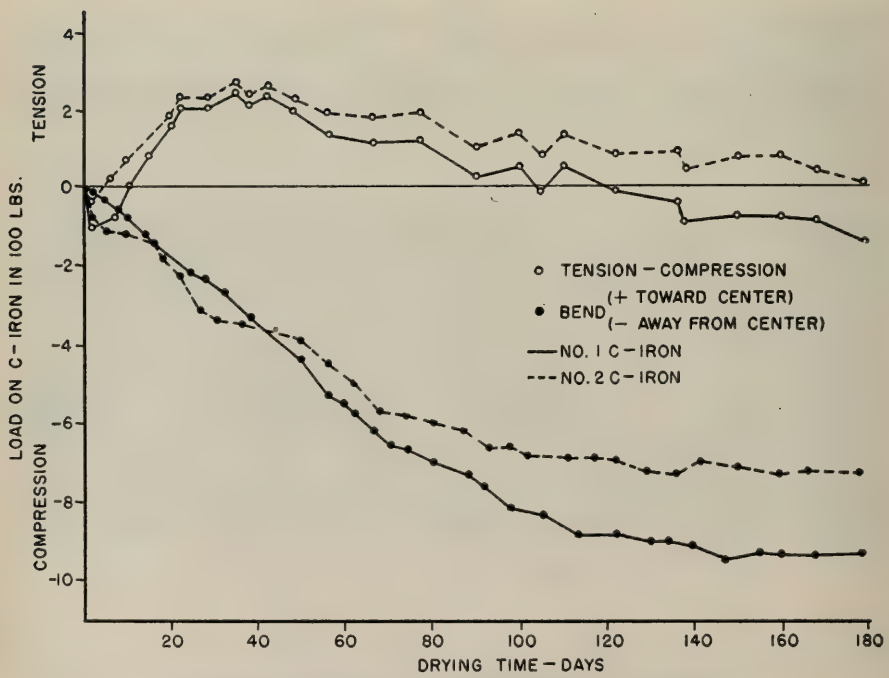

FIG. 3.– STRESS DEVELOPMENT ON C-IRONS DURING SEASONING.

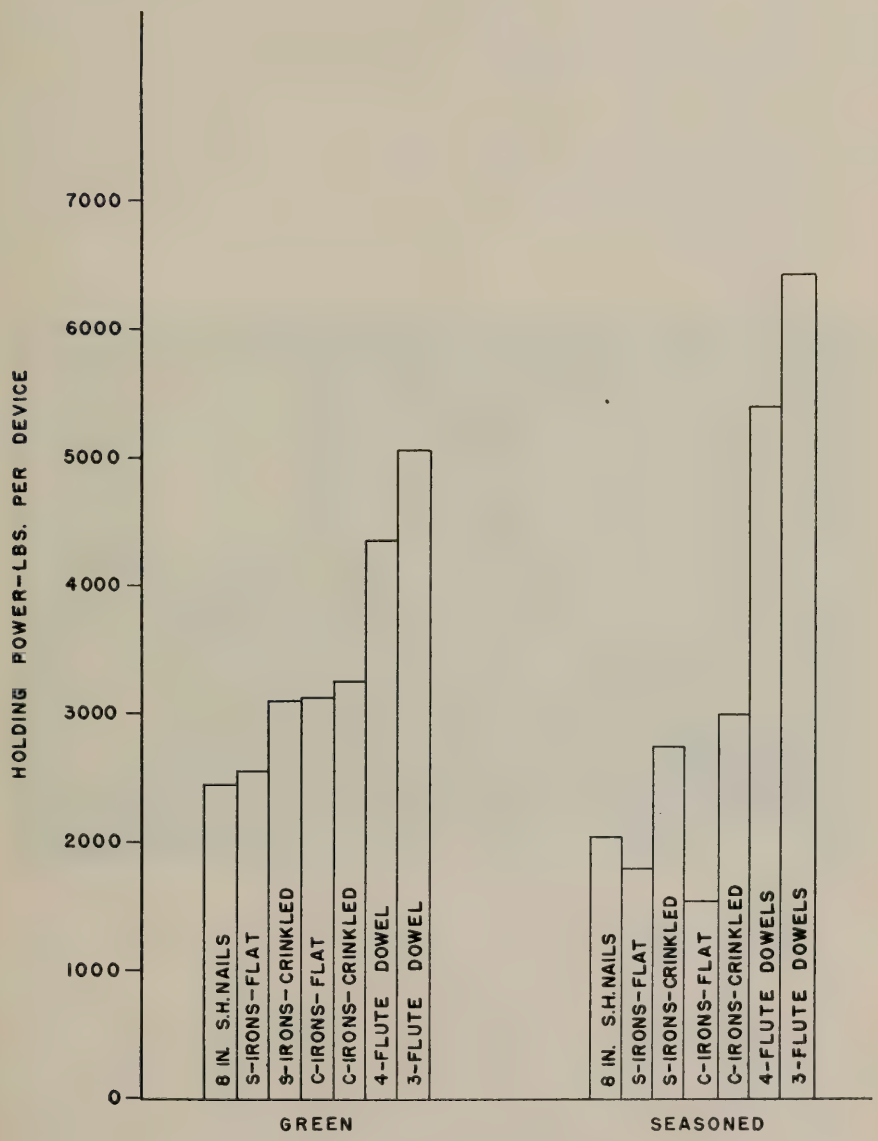

FIG. 4 — HOLDING POWER OF ANTI-SPLITTING DEVICES

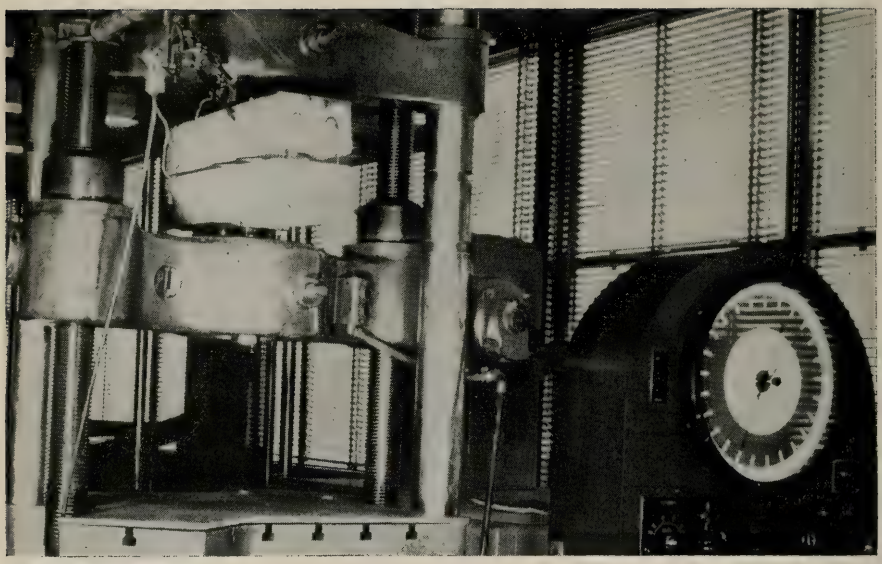

Fig. 5—Pull-test specimen in Baldwin testing machine.

Advance Report of Committee 3—Ties

F. J. Fudge, *Chairman*

Improving the Service Life of Cross Ties—10-Year Summary Report*

By T. G. Gill

Laboratory Manager, Timber Engineering Company

Objective

The purpose of this research program was to study and develop methods of treating and/or modifying wood used for cross ties to produce increased service life of ties in track.

Introduction

The project was sponsored jointly by the National Lumber Manufacturers Association and the Association of American Railroads. The development work was carried out at the Timber Engineering Company research laboratory with the objective of studying and developing methods of treating (other than with preservatives) and/or modifying the wood used for cross ties to increase their in-track service life.

The program was organized in 1946 and 1947, and actual laboratory work was started in 1948. The work was supervised by an administrative committee of NLMA and AAR representatives. The first meeting was held May 3, 1948, and semi-annual meetings were held thereafter to review the work accomplished and to outline future work. The two principal endeavors of the program were: first, to determine means of preventing tie checking and splitting; and, second, method of preventing or controlling tie plate cutting.

The early work consisted of field investigations and a survey of literature. At the same time, laboratory work was initiated to reduce checking and splitting, exploratory work on laminated and composite ties was started, and experiments were conducted aimed at improving penetration of wood by liquids through the use of supersonic treatment. Although this was found to be impractical at the time, it led to the study of non-destructive testing of wood and wooden parts.

Investigations on the causes of cross-tie deterioration indicated that multiple forces worked simultaneously to produce accelerated deterioration of the tie. Among these were indicated losses in chemical stability of the wood under the tie plate area and in the fastener areas. Based on these investigations, a paper was presented before the Division of Industrial and Engineering Chemistry, American Chemical Society. This paper provoked considerable interest among persons concerned with metal-to-wood fasteners under conditions of severe exposure.

Studies were initiated on coating the top surfaces of ties in track to prevent checking and splitting of ties in service. A specification for tie coatings was drafted, which was adopted by the American Railway Engineering Association and published in its Manual in 1957. Many of the major railroads now have track tests in progress, using a number of different coatings. Work on this program at the Timber Engineering Company laboratory acted as the screening agent for coatings for the railroads.

End treatments and partially controlled ventilation systems showed little or no promise in preventing splitting during air seasoning of cross ties. Work was initiated

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July 7, 1958.

on a rapid, artificial method of drying green cross ties. This later developed into what is now known as the Combined Seasoning and Treating Process. The process was patented on October 13, 1953, U. S. Patent No. 2,655,454.

In other phases of the study, procedures were developed to waterproof electrical strain gages so that the moisture in the wood would not cause erroneous readings. Electrical strain gages were then used to obtain data used in laboratory and field studies and in proposed typical designs for an engineered, laminated tie using low-grade lumber cores. In 1952, 120 laminated ties were made at the laboratory and are now under test.

Early in the program it was necessary to develop a method for the accelerated testing of full-size (cross sectional) cross ties. This was accomplished by modifying an AAR rail-testing machine. This machine was housed in a special building and was kept in continuous operation in testing various tie plate area treatments.

A. CROSS-TIE DETERIORATION

Objective

Investigations in this phase of the program were undertaken for the purpose of determining the causes of cross-tie failure and to familiarize Timber Engineering Company personnel with cross-tie problems.

Summary

Work performed consisted of field trips, microscopic and macroscopic evaluation of ties removed from track, duplication of service failures in experiments at the laboratory, and investigations of the chemical deterioration of cross ties.

It was found that the rate of plate cutting is dependent upon the species used, the variation of physical properties within a species, the total load (tonnage) over a track, the size of the tie plate, the type of tie plate fastener, the condition and type of roadway, size of rail, the direction and intensity of prevailing winds, the location of the tie in the track (i.e., on a tangent or curve), etc.

Investigations

Field Trips

Field trips were made to observe the deterioration of cross ties under a variety of geographical conditions and under various service conditions within the geographical locations. These service conditions included tie useage in tangent and curved track, switches, high- and low-speed track, bridges, cuts, fills, level country, desert, and mountainous areas.

During the field trips, efforts were made to determine the cause for removal of cross ties from service. In addition to first-hand observation, unpublished material and local records were examined.

Some of the railroads visited in the performance of this part of the program are as follows:

Illinois Central Railroad
Chicago, Burlington & Quincy Railroad
Pennsylvania Railroad
Atchison, Topeka & Santa Fe Railway
Northern Pacific Railway
Missouri Pacific Railroad

Fig. 1—Plate cutting in a pine tie after 24 years of service.

Macroscopic Examination of Ties Removed from Track

The objective of this phase of the investigation was to determine the extent, type, and distribution of visible failures in ties removed from service. It was found that the major visible reasons for removal of railroad ties from service were mechanical wear on the ties as a result of movement of fasteners, tie plates and roadbed, and the weathering of the tie or the effects of moisture changes.

Forty-nine ties were sent to the laboratory of the Timber Engineering Company. These ties were selected as being typical of those which had been removed from service. Oak, beech, southern pine, western larch, ponderosa pine, and Douglas fir were the species represented.

Tie plate cutting was severe on practically all the ties received. An abundance of foreign material, such as corrosion products from the tie plate and spikes, mineral particles from the ballast, coal dust and sand, were found under the tie plates. Sand was found at various depths under the plate wherever the wood fibers had been separated by checks and splits. Splitting and shattering of the ties was also rather common. The ties inspected at the laboratory were as much as 1 in wider at the top than at the bottom because of the checks and splits in the upper surface. Weathering was very noticeable on ties that had experienced 15 to 20 years of service; they appeared bleached, some surface fibers could be removed easily with mild abrasion, and numerous checks were visible on the surface.

Microscopic Examination of Ties Removed from Track

It was the objective of this portion of the project to conduct a microscopic study of the wood under the tie plate area of ties removed from service for the purpose of determining the type and extent of failure.

Crushing, lateral shifting, and buckling were the main types of failure observed in the tie sections investigated. Lateral shifting of the wood cell structure was confined

Fig. 2—Severe plate cutting in an oak tie removed from service.

mainly to oak springwood and was accompanied by compression ranging from slight to severe. Crushing failures were exhibited in many softwoods in conjunction with lateral or diagonal slippage of springwood areas of cells. Beech and gum ties showed evidence of buckling of medullary rays with or without crushing of springwood cells. Analysis of oak ties from curved track indicated that the low end of the tie received more damage in low-speed areas. In high-speed, curved-track areas, little difference in magnitude of failure in either end was noted.

The railroad ties used in the microscopic examination were the same ones which had been used in the foregoing investigation of readily visible types of cross-tie failure. These ties were cut into sections for processing and chemical softening. Microtome blocks were sectioned and permanent slides prepared of the ties under investigation. These slides were examined under a microscope to determine the type of wood failure which had occurred to cause the railroad tie to be removed from service.

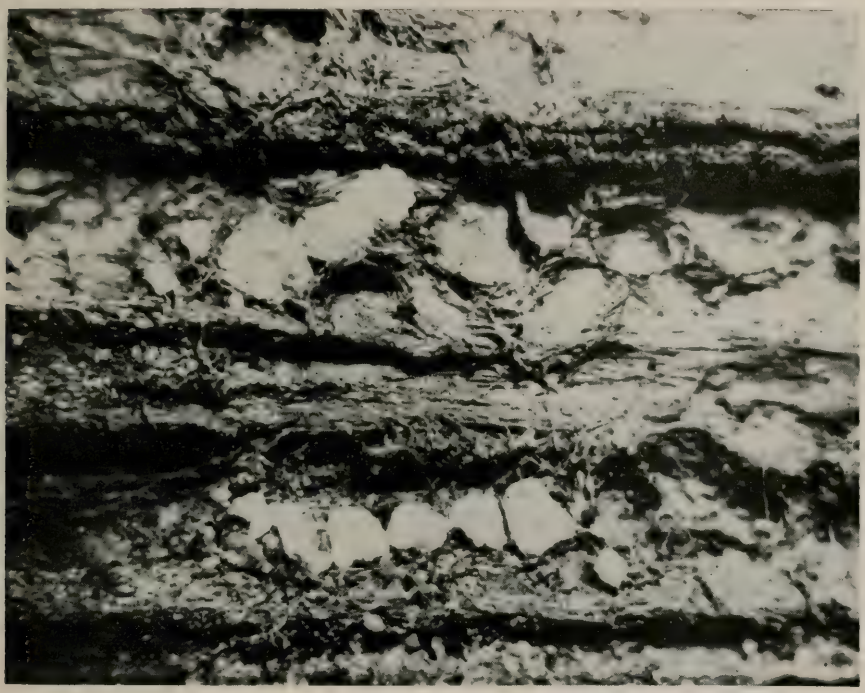


Fig. 3—Photomicrograph of wood from under the tie plate area of a damaged tie showing mineral particles imbedded in the wood.

Duplication of Service Failure in Laboratory Experiments

The objective of this part of the program was to duplicate the failures observed in railroad ties removed from service so that laboratory testing means could be developed for the evaluation of new methods of increasing the service life of cross ties.

The laboratory was successful in duplicating the type of springwood failure that had been observed in microscopic studies of plate-cut oak and Douglas fir ties. Small laboratory-scale experiments employing static and impact loads produced lateral shifting of the kind found in plate-cut oak ties, and crushing, shifting failures of the type observed in Douglas fir ties removed from service.

It was found that loads required to produce failure had to exceed 1.5 times the proportional limit of the wood in oak and 1.3 times the proportional limit in Douglas fir. Loads greater than 2 times the proportional limit produced severe failure in both species.

Chemical Deterioration of Ties

The objective of this study was to determine if there were changes in the chemical composition of wood ties while in service.

Chemical analysis revealed significant changes in the chemical composition of spent cross ties, particularly in the portions of the tie adjacent either to the tie plate or the spikes. Iron was found in these regions in at least two chemical forms. In these

Fig. 4—Severe lateral shifting or ring shear in the springwood of red oak tie removed from service because of plate cutting.

areas it was found that the hemicelluloses had become more subject to hydrolyzation than normal, indicating that an important fiber bond in the wood of the cross tie had become weakened.

Seven expended cross ties were used in this chemical analysis program. The analytical methods used consisted of extraction, dilute hydrolysis, concentrated hydrolysis, flotation, and alkaline extraction. These steps were taken to determine the proportions of hemicellulose, cellulose, and lignin of the samples to determine the presence and amounts of foreign mineral materials in the wood, and to determine the amount of impregnating materials in the wood. Since the proportions of hemicellulose, cellulose, and lignin for a particular species is known and constant, within limits, for wood as it leaves the tree, analysis for these proportions was indicative of the presence of chemical changes in the wood.

References

1. Improving the Service Life of Cross Ties, First Progress Report, October 11, 1948, page 4.
2. Improving the Service Life of Cross Ties, Second Progress Report, December 2, 1949, page 4,

B. DETERIORATION OF WOOD IN CONTACT WITH IRON

Objective

The objective of this investigation was to determine the influence of iron on the chemical composition and mechanical properties of wood and to attempt to develop preventive measures for iron-influenced changes in wood.

Summary

It was found that iron in contact with wood accelerates the oxidation of wood. The rate of deterioration of red oak in the presence of iron is a rather slow process, but a marked change was found in the proportions of hemicellulose and cellulose in the wood after the wood had been in contact with iron for a 16-month period.

The toughness of red oak was reduced considerably by exposure, at high moisture conditions and in the form of thin strips, to the influence of iron.

Pre-treatment of the wood with calcium carbonate substantially reduced the quantity of iron acquired by the wood. Indications of the investigation are that means of preventing chemical deterioration of wood in contact with iron can be developed either by improving techniques with calcium carbonate or by the use of other chemicals.

Investigations

Tests to Determine the Effect of Ferrous Metals on Wood

A series of experiments was conducted to determine the chemical changes of wood in the presence of iron. In this work, the wood species used was red oak in the form of veneer, panels, and ground wood.

Tests on Red Oak Veneer

Veneer specimens were maintained in intimate contact with particles of metallic iron under high moisture conditions for a period of 10 weeks. At the end of this time, toughness tests were conducted using this iron-altered wood and control specimens which had been stored under similar conditions without contact with iron. Although the control specimens exhibited a loss in toughness when compared to freshly prepared specimens, this loss in toughness was less than half the loss in toughness of the iron-influenced specimens. The type of failure typical of the specimens altered by iron was short and brittle, whereas the controls showed a splintering type of break.

In an attempt to find a preventive for the deteriorating effect of iron on wood, a series of tests was conducted using red oak veneer in contact with iron. Small quantities of various materials under investigation were added to the wood to determine their effectiveness in preventing a chemical change in wood. The action of calcium carbonate in reducing iron acquired by wood was very pronounced. Diphenylamine was found to be active as an inhibitor when used in amounts greater than that of calcium carbonate; zinc stearate and Victamide (an amide of phosphoric acid) were effective to a lesser extent.

Tests on Red Oak Panels

Tests were performed using red oak panels which had been stored outside for 16 months under a railroad tie plate. In this quiescent contact with iron, the wood developed organic iron compounds and an apparent loss of cellulose. In red oak specimens which were similarly handled, except for a pre-treatment of the wood by dipping in lime water, the pickup of iron was reduced, and there was no appreciable loss in cellulose.

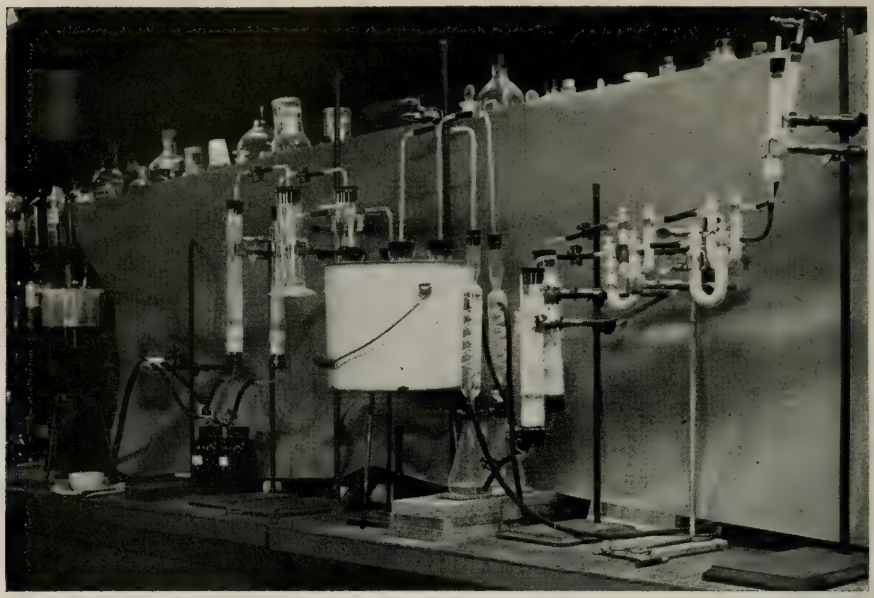


Fig. 5—Apparatus used to evaluate the effectiveness of various chemical agents in alleviating the undesirable influence of iron on the deterioration of wood.

Accelerated Tests Using Ground Red Oak Wood

A series of tests was run in which the production of carbon dioxide was used as a measure of the degree of oxidation of wood. Ground wood was subjected to a controlled circulation of moist air through a closed system. Differences in the production of carbon dioxide by ironfree wood and by wood in contact with iron is then attributable to the presence of iron. Four parallel tests were performed using controls and several materials under investigation as inhibitors of the accelerated deterioration of wood in contact with iron. Results of the experiment verified findings in former work that wood deterioration is accelerated in the presence of iron. The materials under test—calcium carbonate and sodium pyrophosphate—were ineffective, as used in this test, to minimize or prevent the catalytic action of iron on the breakdown of wood.

References

Improving the Service Life of Cross Ties:

1. Second Progress Report, December 2, 1949, page 48.
2. Third Progress Report, February 5, 1951, page 4.
3. Fourth Progress Report, February 8, 1952, page 114.
4. Fifth Progress Report, December 5, 1952, page 101.
5. Summary Report, June 21, 1957, page 5.

C. COMBINED SEASONING AND TREATING

Objective

The objective of this phase of the program to increase the service life of railroad cross ties was to develop a method of seasoning cross ties in which the checking and splitting of the ties during the drying process would be reduced to a minimum.

Summary

This was the most important phase of the research program. A process of combined seasoning and treating of green ties was developed, beginning with small-scale laboratory experiments, further refined and improved in pilot-plant operations in the Santa Fe treating plant at Albuquerque, N. Mex. Finally 2500 oak ties were seasoned and treated in a commercial plant operation by the PRR and IC railroads and installed in heavy-duty track for observation of service performance. Although the process was developed to give satisfactory seasoning and treating, it was not economical compared to the other methods that would accomplish equal results.

Investigations

Fundamental Laboratory Research

Preliminary tests on a laboratory scale were concerned with the discovery of a material which, when added to the solution in which ties are preservatively treated, would miniminze or prevent checking or splitting of the tie. It was determined that the addition of 1 part of ethylene glycol to 10 parts 60/40 creosote-coal tar resulted in satisfactory rapid seasoning of small red-oak samples when the combined treating solution was heated to a temperature above the boiling point of water for a period adequate for the evaporation of excess water from the wood sample.

A variety of materials were tried, including Glycol "R", a residue from the manufacture of ethylene glycol. It was found that Glycol "R" was as effective as tehylene glycol in permitting rapid seasoning of red oak without undue damage to the wood. During this phase of the work, it was also determined that the combined seeasoning and treating solution could be used repeatedly, if a quantity of additive (Glycol "R") were added to the old solution in the amount of 5 percent of the oven-dry weight of the tie which had been treated, and if enough 60/40 creosote-coal tar were added to bring the total weight of the treating solution up to its original weight.

Laboratory Pilot Plant Work

Work at the laboratory of the Timber Engineering Company substantiated, on a pilot-plant scale, the conclusions drawn from the smaller-scale laboratory work in the development of a rapid seasoning process which resulted in a minimum of checks and splits in the wood being seasoned. It was verified that the addition of the Glycol "R" to 60/40 creosote-coal tar solution allowed water to be removed from the wood being seasoned, through high-temperature evaporation, without undue damage to the wood. It was also confirmed that the combined treating solution could be used repeatedly through the replenishment of the Glycol "R" consumed during seasoning.

Larger equipment was used in the pilot plant phase of the program. In this work, a specimen equal in size to one-half of a standard cross tie could be seasoned. Various species of wood were used in the tests to determine differences between species in the degree of success with which they could be rapidly and safely seasoned. Additives other than Glycol "R" were used in an attempt to reduce the cost of combined seasoning

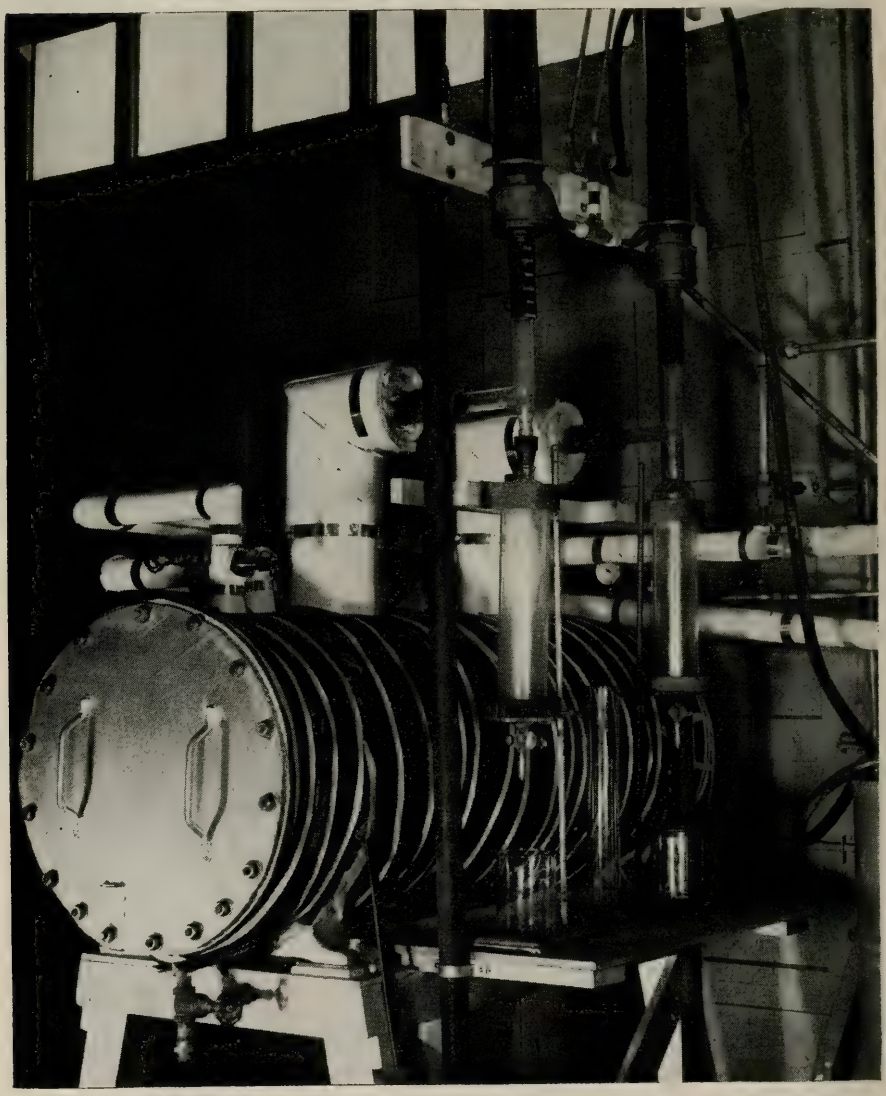


Fig. 6—Laboratory pilot plant apparatus used in the development of the Combined Seasoning and Treating Process for railroad ties.

Fig. 7—Equipment used in the evaluation of the Combined Seasoning and Treating Process on a commercial pilot plant scale.

and treating. The laboratory tests again were verified in that the other materials tested did not minimize nor prevent checking and splitting of the ties during seasoning.

Commercial Pilot-Plant Work

The objective of the commercial pilot-plant work was to process a number of full-size ties by combined seasoning and treating, using commercial equipment to determine the feasibility and economics of the process from a commercial basis.

Commercial pilot-plant tests were made in two locations; at the Atchison, Topeka & Santa Fe treating plant at Albuquerque, N. Mex., and at the Koppers Company treating plant at Orrville, Ohio.

Atchison, Topeka & Santa Fe Tests

A total of 576 ties, consisting of 200 oak, 212 gum, 64 southern yellow pine, and 100 Douglas fir, were seasoned from the green state to a moisture content suitable for pressure treatment and then pressure-treated in the experimental cylinder of the treating plant of the Santa Fe at Albuquerque, N. Mex. The solution used for processing these ties was a 30 percent creosote—70 percent petroleum oil solution with 3 to 10 percent ethylene glycol. The ties were pressure-treated after seasoning with 30/70 creosote-petroleum oil solution.

Fig. 8—Test section on an Eastern railroad of ties seasoned by the Combined Seasoning and Treating Process.

At this time, conclusions were drawn that the combined-seasoning-and-treating process appeared to be technically feasible, with seasoning time in the neighborhood of 10 to 11 hr. It was concluded that within 24 hr after green ties were delivered to a treating plant they could be seasoned and treated and be ready for shipment to the railway for installation in the track. It was determined that no more than 5 lb of glycol per tie were required to minimize satisfactorily the splitting of the ties during seasoning.

Of the 576 ties treated at Albuquerque, 468 were placed in track on the Santa Fe system about 6 miles west of Emporia, Kans.; the rest were used for observation or testing.

Pennsylvania Railroad–Illinois Central Railroad Tests

Two-thousand ties, red and white oak, were treated in a cooperative study with the Pennsylvania Railroad at the Koppers Co. plant at Orrville, Ohio. Fifteen-hundred ties were processed for the Pennsylvania Railroad; an additional 500 ties were requested by the Illinois Central Railroad.

The ties were processed in treating equipment normally used for treating large specialty items. The seasoning medium was 60/40 creosote-coal tar with Glycol "R" added. The Glycol "R" was fortified after each charge, the amount added being dependent upon the weight of the wood seasoned; the amount of Glycol "R" after the first charge was 4.8 lb per tie. Distillation of water from the ties was continued until a predetermined amount of condensate was collected in a calibrated receiver.

The seasoning time varied somewhat, depending upon the operating conditions and, in a normal operation, would be approximately 17 hr. The pressure treatment was the

standard Pennsylvania Railroad schedule of 6 lb/cu ft of 60/40 creosote-coal tar mixture. The combined seasoning and treating time was less than 24 hr.

Penetration and distribution of creosote in glycol-seasoned ties was very satisfactory and, in this instance, somewhat better than in the comparable air-seasoned ties. Surface checking was practically eliminated; however, end splitting was more prominent than had been observed in previous tests, but was not generally considered to be particularly serious.

Biological Evaluation of the Combined Seasoning and Treating Process

The purpose of the biological evaluation program was to determine if the addition of glycol to the treating solution had a deleterious effect upon the decay-preventing properties of creosote-coal tar solution.

It was found that, when either 5 or 10 percent glycol was added to 60/40 creosote-coal tar, the test blocks so treated, when subjected to severe decay conditions, were as well protected against decay as test blocks treated with straight 60/40 creosote-coal tar; the retentions of creosote-coal tar in all cases being equal.

The Leutritz Soil Block Evaluation method was used in this study. In this method, the test blocks are exposed to several species of decay fungi for a period of time adequate for untreated control blocks to be attacked severely.

Three series of test blocks were used in this test, in addition to the untreated controls. These were treated with: (1) 60/40 creosote-coal tar; (2) creosote-coal tar with 5 percent added ethylene glycol; and (3) creosote-coal tar with 10 percent added ethylene glycol. Three species of wood-destroying fungi were used as the test organisms.

After being in contact with infected wood strips on moist soil for 46 days, the blocks were removed from culture, conditioned to equilibrium, and weighed to determine loss in weight due to decay. It was concluded that there was no significant difference in the toxicity of creosote-coal tar and that of creosote-coal tar with 5 percent or 10 percent added glycol.

Strength Tests Comparing Combined Seasoning and Treating Processed Ties with Air-Dried Ties

The purpose of this investigation was to determine the effect of the combined seasoning and treating process on the mechanical strength of cross ties. Both the effect of the over-all process and its component parts were investigated.

Standard Mechanical Tests

Tests for toughness and for compression perpendicular to the grain were performed on standard-size specimens which had been cut from ties treated through the combined seasoning and treating process. Further specimens were also tested in which the treating solution was plain water and in which the treating solution was a water-glycol mixture. Also tested were sections of a tie treated by the combined seasoning and treating process and exposed to the elements for 10 months, and a vapor-dried tie which had been exposed for 24 months.

The tests indicated that there was a loss of strength of from 2 to 25 percent in the ties which were treated by the combined seasoning and treating process within a few days of treating. The combined seasoning and treating processed tie which had been exposed to the weather showed no apparent weakening. Tie sections which had been treated with plain water and a mixture of water and glycol showed no apparent weakening. The vapor-treated tie showed a reduction in strength corresponding to the combined seasoning and treating processed tie as tested immediately after treating.

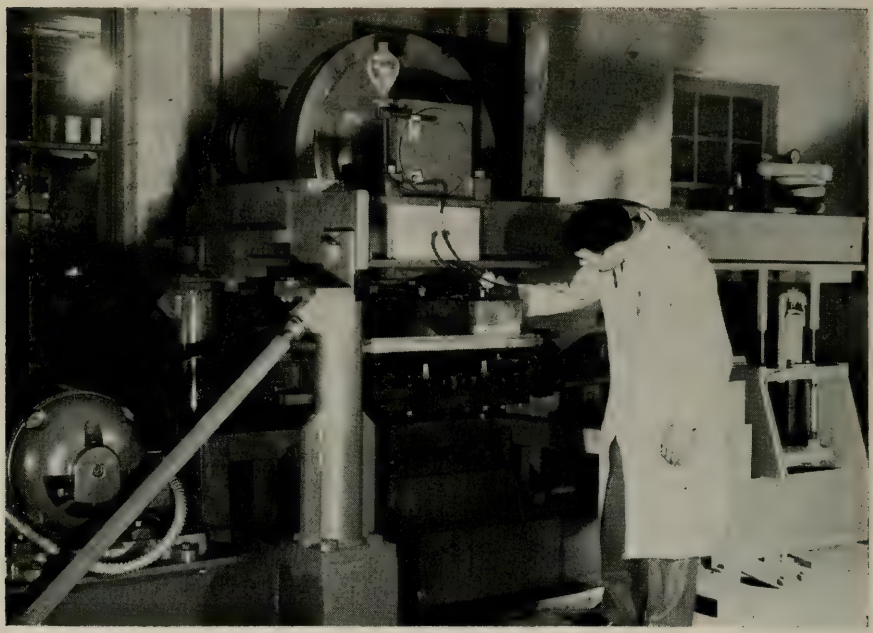


Fig. 9—The Sonntag Universal fatigue testing machine in which accelerated tests of cross ties were conducted, using a rolling load.

Accelerated Tie Testing

Tie sections were tested on the Sonntag universal fatigue testing machine to determine the relative resistance to mechanical wear of ties processed by the combined seasoning and treating process and of comparative ties air-seasoned and preservatively treated.

In general, ties seasoned by the combined seasoning and treating process or by air drying equally resist tie-plate penetration, provided the artificial drying process does not progress to the point where severe honeycombing develops in the tie. When this occurs, compression failure of the tie develops when tested in the rolling-load machine.

Comparative Bending Tests of Oak Ties

The purpose of these tests was to compare the bending strength of air-dried red and white oak ties treated by the normal Rueping process with similar ties processed using the combined seasoning and treating method.

Twelve creosoted cross ties each of red and white oak were used in this study; six of each species were treated by the combined seasoning and treating method, and six of each species were treated by the air-drying process. All ties were tested to failure, in static bending, by center-loading over a 60-in span, to determine the effect of the treating process used.

Both red and white oak ties, air-dried and then pressure-treated using the Rueping process, developed approximately 20 percent greater ultimate breaking strength than oak ties of the same species group treated by the combined seasoning and treating

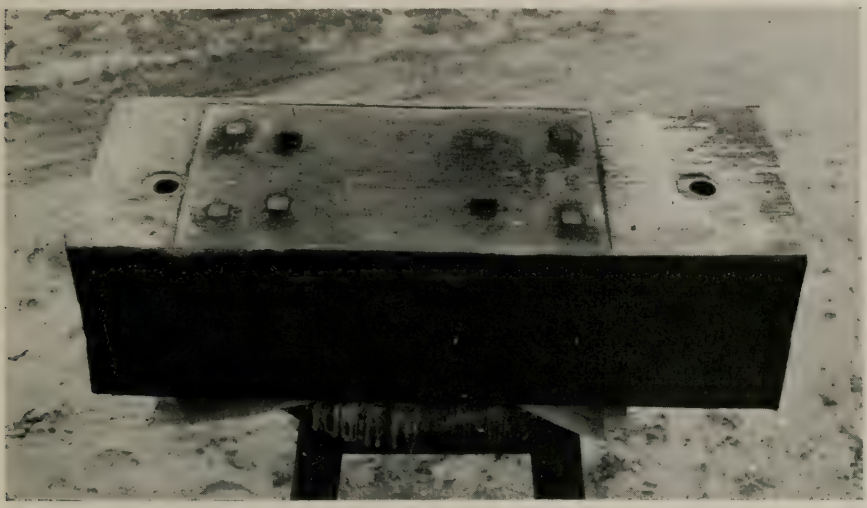


Fig. 10—Tie section after accelerated testing in the Sonntag machine. Note the penetration in the tie plate area.

process. The air-dried creosoted ties had 10 to 15 percent higher bending-stress values at proportional limit than combined seasoned and treated ties. Tests were conducted about 2 months after treating.

Economic Evaluation of Combined Seasoning and Treating

The economics of the combined seasoning and treating process were analyzed in this part of the program.

It was determined that the economic advantages of seasoning ties artificially by the combined seasoning and treating process, i.e., the advantages gained by the necessity for a smaller tie inventory and less loss through splitting and checking, were not sufficient to offset the high price of the drying agent used in the process. To be economically feasible and directly competitive with air seasoning, the cost of the drying agent for the combined seasoning and treating process should not be more than approximately 2 cents per cu ft. Glycol "R", the least expensive of the drying agents determined to be effective in the combined seasoning and treating process, costs about 12–16 cents per cu ft of cross tie treated.

Comparative cost figures show that drying cross ties by the combined seasoning and treating process costs 25 cents per tie more than drying by the vapor-drying process.

Estimates of the cost of air-drying ties, considering handling, interest on ties in storage, insurance and fire protection, tie loss in storage, and doweling costs, range from 20 to 45 cents per tie. Seasoning artificially by the combined seasoning and treating process costs approximately 87 cents more per tie.

References

Improving the Service Life of Cross Ties:

1. Second Progress Report, December 2, 1949, page 87.
2. Third Progress Report, February 5, 1951, page 20.

3. Fourth Progress Report, February 8, 1952, page 77.
4. Fifth Progress Report, December 5, 1952, page 6.
5. Sixth Progress Report, December 4, 1953, page 3.
6. Seventh Progress Report, November 19, 1954, page 3.
7. Eighth Progress Report, November 17, 1955, page 7.
8. Ninth Progress Report, January 10, 1957, page 19.
9. Summary Report, June 21, 1957, page 33.

D. DESIGN OF CROSS TIES

Objective

The objectives of this portion of the program were to study the stresses developed in railroad cross ties under actual service conditions and to develop new designs or modifications to produce longer tie service life.

Summary

Stress measurements and analyses were made to determine the service stresses in ties. Prior to the actual field work, it was necessary to develop a method of using electrical strain gages that would prevent erratic gage readings caused by the effect of

Fig. 11—Fabrication of laminated cross ties—adhesive application.

Fig. 12—Fabrication of laminated cross ties—curing.

moisture in the wood. Information obtained in the field was confirmed by laboratory work, and several designs of composite ties were developed.

A straight, laminated tie design was selected for field tests. One-hundred-twenty laminated ties were made using several combinations of species of wood. These ties have now been in track approximately 3 years and their general condition is the same as at the time of their installation.

In another field test, a small number of ties were fitted with wooden tie inserts, and the effectiveness of the inserts on the prevention of plate cutting was studied.

Investigations

Determining Strength Requirements

Field work, using electrical strain gages attached to a railroad tie, was made possible by the Engineering Division, Association of American Railroads. A study of the oscillograph records made during these tests showed that stresses set up in the tie by passing trains did not exceed the strength of red oak, at proportional limit, in bending or compression perpendicular to the grain. However, the maximum values were higher than the average strength of some other species used for cross ties. Considerable vibration was noticed as trains were passing over the tie. The records also showed

Fig. 13—Fabrication of laminated cross ties—clamping.

Fig. 14—Tie inserts in service test.

that there are many reversals of stresses which may, over a period of time, tend to weaken the wood. With the information gained in this field study, combined with confirming laboratory work, several designs were developed for laminated cross ties, in which the computed stresses which would be developed were not greater than the strength of the potential cross tie material. Diagrams and descriptions of composite ties are given in the Fourth Progress Report, dated February 8, 1952,, pages 68–76.

Laminated Ties

A total of 120 ties were laminated to American Railway Engineering Association size specification for a No. 5 tie—7 in deep, 9 in wide, and 8½ ft long. Fifty of the laminated ties had tupelo gum faces with Douglas fir inner laminations, 50 had tupelo gum faces with southern yellow pine inner lamination, and 20 were made entirely of red oak laminations.

After fabrication, the ties were preservatively treated and placed in service in the Pennsylvania Railroad right-of-way east of Altoona, Pa.

Periodic examinations were made of the ties. After 23 months in service for the softwood-cored ties, and 37 months in service for the red oak laminated ties, their general appearance was the same as immediately after installation.

Tie Inserts

In a secondary phase of this program, the effectiveness of tie inserts in preventing plate cutting was studied. Twelve hickory inserts were prepared at the Timber Engineering Company laboratory and sent to the Northern Pacific Railway with instructions for attachment to the tie. The Northern Pacific made additional inserts of maple and Douglas fir following the pattern of the hickory inserts. These inserts were applied on April 14, 1949, on 15 Douglas fir ties using the standard Northern Pacific rail and plate spiking schedule. No special fastening device was used for the inserts. After 4½ years in service, these inserts were still giving very satisfactory service.

The Northern Pacific inspection report, dated September 25, 1958, indicated that after 9½ years in service, all the inserts were split. However, it further states, "Except for the splitting and checking, the inserts are in good condition. There is no evidence of wear or other deterioration between the tie plates and the inserts with the exception of the right insert on tie No. 14, which is starting to show plate cutting." Inserts on tie No. 14 are Douglas fir; all others are hickory or maple.

References

Improving the Service Life of Cross Ties:

1. First Progress Report, October 11, 1948, page 52.
2. Second Progress Report, December 2, 1949, page 102.
3. Third Progress Report, December 5, 1951, page 50.
4. Fourth Progress Report, February 8, 1952, page 36.
5. Fifth Progress Report, December 5, 1952, page 81.
6. Sixth Progress Report, December 4, 1953, page 41 and 51.
7. Seventh Progress Report, November 19, 1954, page 57 and 66.
8. Eighth Progress Report, November 17, 1955, page 95.
9. Ninth Progress Report, January 10, 1957, page 47.

E. EVALUATION OF TIE COATINGS

Objective

The objective of this investigation was to evaluate the ability of tie coating materials to reduce splitting and weathering of cross ties in service.

Summary

A tie-coating test area was set up in the Timber Engineering Company yard to evaluate various materials for tie coatings. Approximately 40 proprietary compounds were in the test at one time or another. Information obtained from this test and from rather extensive field investigations formed the basis of the tie coating specification recently adopted by the Tie committee of the American Railway Engineering Association, and published in the AREA Manual.

Investigations

Work on the evaluation of tie coatings was carried on in two locations: the tie test yard at the Timber Engineering Company Research Laboratory, and a test section in service on the right-of-way of the Louisville & Nashville Railroad.

Laboratory Exposure Tests

Forty tie-coating materials were tested at the laboratory of the Timber Engineering Company. The tie-coating exposure area was approximately 1900 sq ft. This entire area was filled with 6 in of rock ballast. The test specimens were 24-in sections of No. 5, 7 by 9-in, cross ties commercially treated with 8 lb of 70/30 creosote-coal tar solution per cubic foot. These sections were embedded in the ballast approximately 4 in.

Coatings were applied by brush in warm weather. Checks and splits were first filled with the coating, and then the entire section (top and ends) was given approximately an average ⅛-in coating with a thicker layer in the mid-section feathering out to the edges.

Information as to the name, manufacturer, method of application, and type of material of each of the tie-coating materials is contained in Table 1. Measurements were made semi-annually of the width and depth of all checks over ⅛ in wide in the coated ties and their uncoated controls, and observations were made as to the condition of the coatings. The efficiency of each coating, based on the area of checks measured on the end of each tie, was calculated using the following formula:

$$\text{Efficiency index} = \frac{\text{Total area, checks, coated ties}}{\text{Total area, checks, control ties}} \times 100$$

Efficiency ratings, as of September 1957, of coatings which had proved effective as of that time are contained in Table 2.

A "Tentative Specification for Tie Coatings, Their Application and Tests" was developed, based on the results and observations of these tests, for the American Railway Engineering Association in 1953; this specification was adopted as a standard in 1957.

Field Tests

This study was a part of the Association of American Railroad's tests on "Hold-down Fastenings for Tie Plates, Including Pads Under Plates; Their Effect on Tie Wear," on the Louisville & Nashville Railroad.

Two test sections, Nos. 35 and 36, were installed on July 13, 1950. Koppers Com-

TABLE 1—SUMMARY OF TIE-COATING RATE OF APPLICATION, TEMPERATURE OF APPLICATION, TYPE OF MATERIAL, AND SUPPLIER

Compound Number	*Compound Name*	*Temperature of Application Degrees F*	*Rate of Application Lb/Tie*	*Type of Material*	*Supplier*
1	Tie Saver	75	6.0	Coal tar pitch with a filler	Koppers Company
2	Enjay—71/80	300	8.0	Paving asphalt	Esso Standard Oil Company
3	Enjay—MC2	120	5.0	Medium cure asphalt	Esso Standard Oil Company
4	Enjay—RC2	75	2.5	Rapid cure asphalt	Esso Standard Oil Company
5	Baromix Compound	250	8.5	Asphalt compound	Berry Asphalt Company
6	Baromix Liquid	75	7.2	Cut back asphalt compound	Berry Asphalt Company
7	Mexican Asphalt #10	180	6.8	Waterproofing asphalt	Mexican Petroleum Company
8a	RC-2, two coats	75	4.9	Rapid cure asphalt	Esso Standard Oil Company
8b	Protek-coat	75	3.3	Bituminous with fillers	Champion Sales Company
9a	Asphalt with aluminum powder	300	6.0	Baromix with aluminum powder	Timber Engineering Company
9b	Fibered asphalt	240	3.0	Fibered asphalt	Panther Oil & Grease Company
10	71/80 dipped	300	8.9	Paving asphalt	Esso Standard Oil Company
11	No-Ox-Id "XX"	250	3.7	Wax coating	Dearborn Chemical Company
12	Protek-coat	85	3.2	Bituminous with fillers	Champion Sales Company
13	Tie Surfacer	85	1.8	Fibered asphalt cut back	J. W. Mortell Company
14	Kreolite Jennite	85	2.9	Emulsified coal tar	Jennison–Wright Corporation
15	Protek-tie	85	3.2	Bituminous product	Champion Sales Company
16	Osmosplastic	85	5.4	Coal tar base with wood preservative	Osmose Wood Preservative Company
17	Liquid Bridge Cement	85	3.4	Asphalt product with a filler	The Texas Company
18	Liquid Asbestos Cement	85	3.1	Asphalt product with a filler	The Texas Company
19	Vanseal Wax	85	2.8	Wax log end coating	R. T. Vanderbilt Company
20	Allied G-1	250	2.9	Asphalt	Allied Asphalt & Mineral Corporation
21	Rubberized Baromix	85	3.0	Cut back asphalt with rubber	Berry Asphalt Company
22	Caulking Compound #94	300	3.0	Very thick coal tar pitch	Dominion Tar & Chemical Company
23	Caulking Compound #90	200	3.2	Medium thick coal tar pitch	Dominion Tar & Chemical Company
24	Caulking Compound #88a	90	2.1	Thin coal tar pitch	Dominion Tar & Chemical Company
25	Pioneer #607	90	2.1	Acid-proof paint	Witco Chemical Company
26	Pioneer #621	90	1.7	Acid-proof paint	Witco Chemical Company
27	Kreolite Tie-Kote	90	2.8	Coal tar emulsion	Jennison–Wright Corporation
28	Emulsified Asphalt #483B	90	2.6	Asphalt emulsion	American Bitumuls & Asphalt Company
29	Emulsified asphalt #504B	90	3.4	Asphalt emulsion	American Bitumuls & Asphalt Company
30	Texticote #3	90	2.4	Cut back asphalt	The Texas Company
31	Paracol 404-T	75	3.1	Wax emulsion	Hercules Powder Company
32	Tyseal	80	3.1	Asphalt with filler	Chapman Chemical Company
33	Bird Rubberized Tie Coating	80	3.0	Rubberized filled asphalt	Bird & Sons, Inc.
34	Pioneer EC-38116	70	1.6	Asphalt with filler	Witco Chemical Company
35	Pioneer EC-36046	70	2.1	Asphalt with filler	Witco Chemical Company
36	Tie Saver (in checks only)	75	----------	Coal tar pitch with filler	Koppers Company, Inc.

TABLE 2—COMPARISON OF TIE COATINGS AS OF SEPTEMBER 1957, GIVING EFFICIENCY RATING AND NUMBER OF MONTHS IN SERVICE

Compound Number[1]	*Compound Name*	*Number of Months in Service*		*September 1957 Efficiency Index*	*Remarks*
		Total	*Since Recoating*		
1	Tie Saver	98	24	100	Re-coated 9/55—Coating in good condition
2	71/80 Asphalt	98	24	17	Re-coated 9/55—Large checks not filled. Coating in good condition
3	MC-2 Asphalt	98	24	36	Re-coated 9/55—Checks not filled. Coating too thin at 120°F
4	RC-2 Asphalt	98	24	77	Re-coated 9/55—Checks not filled. Coating in good condition but thin
5	Baromix Compound	98	24	100	Re-coated 9/55—Coating in good condition
6	Liquid Baromix	98	24	86	Re-coated 9/55—Larger checks not filled. Good condition
7	Mexican Asphalt #10	98	24	91	Re-coated 9/55—Coating in good condition
8b	Protek-coat	84	24	100	Re-coated 9/55—Coating in good condition
9b	Fibered Asphalt	86	----------	71	Coating weathered, broken over large checks, and chipping
11	No-Ox-Id "XX"	87	----------	100	Coating weathering but no checks appearing in coated sections
12	Protek-coat	74	----------	11	Coating drying out, breaking over checks, and brittle
15	Protek-tie	63	----------	80	Coating in good condition
17	Liquid Bridge Cement	63	----------	79	Coating in good condition
18	Liquid Asbestos Cement	63	----------	100	Coating in good condition
20	Allied G-1	63	----------	100	Coating in good condition
21	Rubberized Baromix	63	----------	100	Coating weathered where application thin, but in good condition
22	Caulking Compound #94	54	----------	68	Coating starting to break over checks
23	Caulking Compound #90	54	----------	90	Coating starting to break over checks
24	Caulking Compound #88a	54	----------	86	Coating broken over checks and weathered
28	Emulsified Asphalt 483B	54	----------	92	Checks not filled by original application. Coating weathering off
29	Emulsified Asphalt 504B	54	----------	66	Larger checks not adequately filled by original coating. Slightly weathered
32	Tyseal	44	----------	78	Coating in good condition
33	Bird Rubberized Tie Coating	24	18	100	Original coat too thin—recoated 3/56 with heavier material. Good condition
34	Pioneer EC-38116	18	----------	100	Coating in good condition
35	Pioneer EC-36046	18	----------	100	Coating in good condition
36	Tie Saver (in checks only)	18	----------	99	Checks opening in center of tie section making caulking compound ineffective (after 3 months)

[1]Compounds numbered 8a, 9a, 10, 13, 14, 16, 19, 25, 26, 27, 30, and 31 were discontinued as not being suitable for tie coatings.

Fig. 15—Tie coating exposure test yard at the Timber Engineering Company laboratory.

pany's Tie Saver Compound, coal tar-asbestos-fibered material, was used in both tests. Section 35 consisted of 120 new ties laid out of face. The odd-numbered ties were coated and the even-numbered ones were left as controls. The tie-plate areas of all ties in this section were coated prior to installing the tie plate. The odd-numbered ties from 1 through 59 were treated on the top surface only; the odd-numbered ties from 61 through 119 were treated on the top and end surfaces. Section 36 consisted of 118 old ties in service for from 2 to 19 years. Ties numbered 1 through 60 were coated on the top surfaces only; ties numbered 61 through 118 were coated on the top and end surfaces.

After seven years of service, the coatings are still effective in reducing the deterioration of the tie from weathering and splitting. Also, the effectiveness of the coatings in maintaining a uniform moisture content in the tie was still very apparent during the 1957 inspection.

References

Improving the Service Life of Cross Ties:

1. Second Progress Report, December 2, 1949, page 77.
2. Third Progress Report, February 5, 1951, page 11.
3. Fourth Progress Report, February 8, 1952, page 6.
4. Fifth Progress Report, December 5, 1952, page 45.
5. Sixth Progress Report, December 4, 1953, page 29.
6. Seventh Progress Report, November 19, 1954, page 25.
7. Eighth Progress Report, November 17, 1955, page 45.
8. Ninth Progress Report, January 10, 1957, page 27.
9. Summary Report, June 21, 1957, page 13.

Fig. 16—Coated ties in service.

F. STRENGTHENING THE TIE PLATE AREA

Objective

The objective of this work was to develop a method for increasing the wear resistance of the wood at the tie-plate area by the use of resins or other toughening agents.

Summary

It had been determined in earlier phases of the program to increase the service life of cross ties that a major portion of the ties removed from service were damaged by plate cutting. As a method of protection against this plate cutting, it was thought that treatment with agents that would toughen this area would be helpful. Although a material was found that could increase the toughness and abrasion resistance of red oak and southern yellow pine, this property of the resin was not effective when used on wood which had been creosote-treated prior to resin impregnation.

Exploratory tests were made on 13 materials, 6 of which were selected for screening tests. The initial tests were made to determine the compatibility of the materials with 60/40 creosote-coal tar solution, and to see if the rate of polymerization could be controlled so as to be suitable for use in toughening and improving the abrasion resistance of wood under the tie plate. Screening tests followed and were based on comparable toughness and abrasion values for treated and untreated specimens.

Two resins, furfuryl and PDO–40 (a polymerized olafinic hydrocarbon) were selected for a complete series of tests, including toughness, hardness and abrasion values. Wood impregnated with furfuryl alcohol catalyzed with nitric acid showed a material decrease in hardness and was eliminated from further testing. Red oak and southern yellow pine impregnated with PDO–40 showed a substantial increase in resistance to abrasion with no decrease in hardness or toughness. However, when the wood was pressure-treated with 60/40 creosote-coal tar solution before treating with PDO–40, not enough of the resin entered the wood to be effective. The resin which did enter the creosoted wood did not cure properly, and its abrasion-resisting properties could not be utilized.

Investigations

Preliminary Tests of Resins

In the preliminary phase, three resins were selected for test based on previous work. The effect on toughness properties was determined by standard toughness-testing methods using a Forest Products Laboratory type of toughness testing machine and ⅝ by ⅝ by 10-in matched red-oak test specimens. The following resins were selected:

1. Piccopale Resin 100 (a new petroleum by-product which is essentially a high hydrocarbon produced by the polymerization of unsaturates derived from the deep cracking of petroleum)
2. Butvar B–76 (a polyvinyl butyral)
3. Alchemite (a vinyl varnish containing about twice as much resin as ordinary synthetic resin lacquers)

For each variable, there were 10 treated specimens and 10 end-matched controls (untreated). Series 1 and 2 were treated with Piccopale containing 60 percent resin; Alchemite containing 40 percent resin; and Butvar containing 10 percent resin. After

the above treatment, following conditioning to constant weight, both the treated pieces and the controls were tested and their toughness values in foot-pounds computed.

Table 3 contains the results of toughness tests and the dry resin retentions.

TABLE 3—RESULTS OF TOUGHNESS TESTS CONDUCTED ON RED OAK IMPREGNATED WITH 3 SELECTED RESINS[1]

Resin	*Dry Resin Retention Percent*[2]	*Toughness*	
		Gain %	*Loss* %
Piccopale 100			
Series 1	12.66	----------	2.8
Series 2	10.17	8.2	----------
Alchemite			
Series 1	10.17	----------	9.2
Series 2	7.43	16.2	----------
Butvar B-76			
Series 1	2.53	19.8	----------
Series 2	2.99	20.6	----------

[1] Results are the averages for 10 specimens.
[2] Based on the weight of wood at 12 percent moisture content.

Butvar B–76 gave the highest increase in toughness, with a relatively low percentage resin pickup. Also, the values of the individual test specimens were quite constant. Piccopale 100 and Alchemite showed large variations between the individual specimens with about 50 percent showing an increase in toughness and the other half showing a decrease.

Screening Tests of Resins

A series of screening tests were performed using toughness as the criterion of acceptability for resins and formulations believed to have promise for treating the tie-plate area. Of the 13 materials tested, six were selected for further tests, as follows:

1. Glyoxal (ethanedial)—a 20 percent solution.
2. Furfuryl alcohol—a 20 percent acetone solution.
3. Furfuryl alcohol—a 20 percent solution catalyzed with 5 percent nitric acid.
4. Diphenylamine—a 10 percent acetone solution.
5. Vinyl acetate monomer catalyzed with 4 percent Alperox-C.
6. PDO-40 (polymerized olefinic hydrocarbon)—a 40 percent acetone solution.

The results of these tests showed that furfuryl alcohol catalyzed with 5 percent nitric acid, and PDO–40 resin were more promising than the other materials for increasing the strength of the wood under the tie-plate area.

To determine the effect of the presence of creosote on the properties of furfuryl resins for detailed study, three series of experiments were made using 60/40 creosote–coal tar and furfuryl resins.

In the first series of tests, 10 red-oak-toughness and 10 red-oak-hardness specimens were dipped in a weak, catalyzed furfuryl alcohol monomer. The catalyst used was 5 percent concentrated nitric acid added 30 parts to 1000 parts of furfuryl alcohol. In the second series, 10 toughness and 10 hardness red-oak specimens were creosote-treated to an average retention of 8 lb/cu ft. In the third series, 10 toughness and 10 hardness

TABLE 4—RESULTS OF TOUGHNESS AND HARDNESS TESTS MADE ON RED OAK IMPREGNATED WITH CREOSOTE AND/OR FURFURYL ALCOHOL[1]

Impregnation	*Average Resin Retention*[2] *Percent*	*Toughness*				*Hardness*			
		Average In-Lb	*Range In-Lb*	*Gain*[3] *%*	*Loss*[3] *%*	*Average Lb*	*Range Lb*	*Gain*[3] *%*	*Loss*[3] *%*
Furfuryl alcohol weakly catalyzed	5.7	259.0	199.4–292.0	24.2	. .	1444	1467–1660	. . . .	6.1
Controls (no treatment)	.	208.6	129.5–253.6	. .	. .	1538	1273–1620	. .	. . . . .
60/40 creosote—coal tar sol.[4]		303.9	253.6–392.0	. .	6.8	1532	1450–1600	. . .	6.0
Controls (no treatment)		326.1	292.0–397.8	.	.	1630	1480–1760	.	. . . . .
Weakly catalyzed furfuryl alcohol and 60/40 creosote—coal tar solution	0.28	248.4	203.0–303.4	2.9	.	1235	1053–1350	. . . .	2.1
Controls (no treatment)	.	241.4	163.0–313.0	. . . . .	. .	1262	1167–1413		. . . . .

[1] Results are average of 10 specimens.
[2] Based on initial weight of wood.
[3] Based on average for untreated controls.
[4] Average retention of 8 lb/cu ft.

Fig. 17—Apparatus for the local impregnation of the tie plate area with toughening resins.

red-oak specimens were first creosote-treated, as above, air-dried for 24 hr, and then given a 10-min dip treatment in furfuryl alcohol. In each series, matched, untreated specimens were included as controls for comparative purposes.

Table 4 gives comparative results of toughness and hardness tests, based on matched controls, on the three series of red-oak wood impregnated with creosote and/or furfuryl alcohol. Red-oak specimens treated with furfuryl only showed a 24.2 percent increase in toughness; test pieces treated with 60/40 creosote-coal tar solutions showed 6.8 percent loss in toughness. Specimens similarly treated with creosote, and then given a 10-min dip in furfuryl alcohol, showed a 2.9 percent increase in toughness, the over-all effect being to bring the toughness of the creosoted wood up to that of the untreated wood. Hardness values were generally lower when creosoted or non-creosoted red-oak specimens were impregnated with furfuryl resin, the decrease varying from approximately 2 to 6 percent. Since both hardness and abrasion values of furfuryl-treated specimens were lower than untreated controls, no further work was done with this resin.

Tests Using PDO–40 Resin on Tie Sections

The PDO–40 screening tests showed more promise than the other resins. Therefore, a complete series of tests was made using red oak and southern yellow pine. These tests included toughness, hardness, and abrasion tests on the following specimens:

1. Untreated controls
2. PDO–40 pressure-treated
3. Creosoted (60/40 creosote-coal tar) pressure-treated
4. Creosoted, as above, then pressure-treated with PDO–40

At the same time, four full-size southern yellow pine tie sections, 7 by 9 by 21 in, were prepared for test. These specimens were previously treated with 10 lb/cu ft of Grade 1 creosote. Using a specially constructed pressure apparatus which spot-treated only the tie-plate area, two of the four test pieces were treated with PDO–40. These resin-treated tie sections and matched control sections were tested in the rolling-load tie-testing machine. The test was run for one million cycles under 20,000-lb load in the usual manner.

Results of toughness, hardness, and abrasion tests conducted on red oak and southern yellow pine specimens with dry resin retentions of 19 and 44 percent, respectively, showed an abrasion resistance over 50 percent greater than untreated wood of the same species, with no significant change in either toughness or hardness. Red oak and southern yellow pine previously treated with 60/40 creosote-coal tar solution before impregnation with PDO–40 did not pick up enough resin to be effective, nor could the small amount of resin retained be adequately cured.

Rolling-load tests using PDO–40 impregnated, creosoted tie sections showed that there was no significant improvement of the PDO–40 impregnated, creosoted ties over the creosoted controls. However, as mentioned previously, the resin did not properly cure when applied to creosoted wood.

References

Improving the Service Life of Cross Ties:

1. Seventh Progress Report, November 19, 1954, page 53.
2. Eighth Progress Report, November 17, 1955, page 89.
3. Ninth Progress Report, January 10, 1957, page 5.

G. THE EFFECT OF ULTRASONICS ON IMPROVING THE TREATABILITY OF WOOD

Objective

The objective of this program for improving the treatability of wood was to develop an economical process for producing deeper and more rapid penetration of treating solutions into those woods that are difficult to treat.

Summary

In an attempt to increase the treatability of refractory woods, the use of ultrasonic vibration of the treating solution was investigated. Various electronic means were used to impart pulsations of very short duration to the treating liquid. Variations in frequency and amplitude of the pulsations, in position of the wood in relation to the treating solution and pulsation generator and in wood species, were all investigated.

Though free water flow in wood specimens could be increased through the use of ultrasonic vibration in a liquid medium, and liquid pickup of easily treated woods was increased over the pickup for a soak treatment of equal duration, the use of ultrasonic vibrations in increasing the treatability of refractory woods was ineffective.

Investigations

Initial Research With a Small Unit Constructed in the Laboratory

A literature survey indicated that the type of vibratory device that would be most likely to produce the desired results would be based on the phenomenon of magnetostriction. In the treatment of wood in these experiments, both the direct and indirect coupling techniques were employed to transmit the vibrations to the wood.

The initial equipment consisted basically of a radio frequency unit and a power supply. From the line source, the power supply produced the desired alternating and constant voltages required for the oscillator which, in turn, generated the radio frequency waves of 10 kc to drive the nickel tube. To maintain 10 kc, a constant magnetic field was impressed on the alternating magnetic field. With the addition of a constant field for polarizing the nickel tube, one mechanical vibration is produced for each cycle of magnetic change.

Inductive heating of the nickel tube was a problem, and it was necessary to introduce a water cooling system to maintain the efficiency of the transducer. The treating cup, a glass cylinder 1¼ in. in diameter, was fitted on the nickel tube and sealed to it on its lower end by a water-tight flexible rubber membrane so that the glass receptacle would hold treating liquids. The cylinder was supported separately from the nickel tube to allow undamped vibration.

Prior to each test run, water or a dye solution was placed in the treating cup to a level just covering the top of the nickel transducer. The block, usually of dimensions of 2 by 2 centimeters and of variable length, was placed in the treating receptacle with the grain parallel to the vertical axis. The block was immediately positioned and the generator power applied. The time required to cause the liquid to rise to the top of the block under accelerated capillary flow was recorded.

The results of tests on various species of easy-to-treat wood showed that there was a definite indication that 10 kc vibration aided free water flow along the major capillary tubes or vessels in wood. This flow was especially rapid for short-length blocks and, gradually, the rate decreased for increasing length until supersonic energy

did not increase free water flow. Any further movement in a treated sample becomes one of capillarity and diffusions as in an unaided control sample. Hard-to-treat woods, such as red gum heartwood, did not show any indication of increased free water flow.

Experiments Using QCR–1 Sonar Equipment

Previous work indicated that a larger generator should be obtained. Through the cooperation of the U. S. Navy, a QCR–1 sonar set was obtained for experimental use to improve the treatability of wood. In principle, the model QCR–1 is similar to the experimental generator developed in the Timber Engineering Company laboratory. Although the tube-and-plate transducer is much larger and more powerful in this set than the vibrator unit used in previous experiments, the power density was lower due to the larger transducer head.

A number of different experimental methods of using this equipment in the investigation of penetration into wood were tried.

Open-Tank Tests

Water absorption characteristics were studied by conducting tests on two series of treated and untreated basswood samples. The first series of tests was conducted in 28 in of water, measured from the projector face to the surface. The specimen was a block 1¾ in square, and 2 in long. Test pieces were located at various distances from the projector; water absorption measurements were taken for a period of 5 to 10 min. Usually, 5 sec was selected for the "off and on" periods for the later runs.

The second series of tests involved a measurement of absorptions obtained by placing one end of the block directly on the projector head with a water level of ¼- to ½-in depth. Sonar energy was applied for 10 min, with 3 pulses a min—a pulse duration of 10 sec and cooling period of 10 sec.

The first series of tests showed no significant difference in moisture absorption percent based on original weight of the samples for each separate test.

For the second series of tests, in which the blocks were placed directly on the projector face in ¼ to ½ in of water, the treated piece showed a greater amount of water absorption than the controls. Usually the values ranged between 30–50 percent increase in the treated specimens.

Since the tests in the open tank showed that differential pressures were more important than the nearly constant ones on all surfaces of the submerged block, study of free water flow with pressure applied only to one surface became necessary.

Closed-Tank Experiments

The closed tank involved a method in which a small, hydrostatic pressure could be applied to a surface of wood by encasing it in a suitable metal jacket and coupling the sonar power to one of the exposed specimen ends through water. The unit, which contained the wood to be studied, consisted of a pipe flange, nipples, reducers, gages and a bleeder valve attached to the lid of the tank. The radio frequency power was transmitted to the projector through an armored cable from the filter junction box. The water pressure was controlled by the faucet pressure and bleeder valve. Clear basswood squares, with a moisture content of 8–10 percent, were turned down on a lathe to produce the cylindrical test specimens.

When the solid wood cylinder had been seated in the pipe, the hydrostatic pressure was applied by filling the tank. With the first appearance of water through the end of the wood, the stop watch was started. Pressure was maintained at the proper level,

usually 2 psi. The water which passed through the wood was collected in a beaker and measured with a graduate to determine the rate of flow.

When the rate of flow had somewhat stabilized, sonar power was applied for a limited time, and the increased rate of flow was measured immediately. These rates were evaluated for a period extending from 10 to 15 min after the sonar equipment had been turned off. Since continuous sonar operation is not advisable due to heating of the projector, manual pulsing was employed which introduced cooling periods for the projector.

In this study, the work was done over a narrow frequency range of 20 to 21 kc, and on one type of equipment. The power density was in the order of ½ w/sq in. Thus, the power available for these studies was low, since much of the 100-w power was wasted by losses incurred in the tank. Nevertheless, two distinct effects could be noted in non-refractory woods. There was, first, a very rapid rise and increase in the free water flow which could not be attributed to pressure alone, but rather to low amplitude vibrations of high frequency. Second, after the sonar energy field had been removed, there was a tapering off of the rate of flow. However, the higher than normal rate of flow tended to continue for 10 to 15 min before reaching the original trend.

The rate of free water flow in refractory woods did not appear to be affected in the methods used in these experiments.

Additional Open-Tank Experiments

In these tests, a smaller testing tank than the one described previously was employed, with the magnetostriction projector or vibrator resting on the bottom in such a position that the sound beam, radiating from the vibrator surface, was perpendicular to the surface of the water covering it. The water level was adjusted so that the surface represented the plane of cavitation with further cavitation planes occurring at half-wave levels or antinodal planes from top to bottom. The samples to be tested were usually placed in small glass beakers, filled with the proper soution, to a level of 1 in and placed in the tank so that the beaker bottom was about ½ in. in the water. The 20 kc vibration was applied as 48 pulses per min for a period of 1 hr; the pulse length being approximately 0.08 sec (or about 4 min out of 60).

The test specimens were blocks 1 in square. The following species were used: red oak, beech, sap gum, balsa, hard maple, cherry, Douglas fir, southern yellow pine, basswood, yellow poplar, northern white pine, heart gum, and heart soft maple. The treating liquids were water, and water and glycol.

The results of water-absorption tests in previous open-tank tests proved to be negative except for the series in which the blocks were placed directly on the projector face in ¼ to ½ in of water. Using the present test procedures, the absorption rate for treatable woods was increased with the sonar equipment, even in cases where the wood was totally immersed.

In some cases, basswood for example, the normal absorption was so great that the ultrasonic power was of no aid in increasing the absorption for the test period of 1 hr. However, as shown in previous experiments, a shorter treating period produces a higher absorption ratio in such easily treatable woods.

Treatments with liquids other than water gave comparable results, the degree of absorption being a function of the chemical and physical nature of the treating liquid.

Work at Brush Development Company

Equipment for ultrasonic studies was made available to the Timber Engineering

Company in the hypersonic laboratory of the Brush Development Company, Cleveland, Ohio, on a cooperative study.

A low-frequency generator was used to drive the ceramic transducers utilized. This type of transducer had certain electrical and physical properties which made it ideal for experimental studies.

Absorption studies of wood by means of the ceramic transducers were set up similar to the tests conducted in the Timber Engineering Company laboratory with sonar equipment. The tests included various treating times and degrees of immersion. The power was varied as to the type of test and transducer element, and was measured indirectly from the volt and ampere meter readings.

The majority of the tests were carried out with the curved-type ceramic transducer which focused the found energy to a point, producing high-intensity values. By varying the distance between the block and the transducer, it was possible to vary the amount of energy imposed on the block in terms of acoustic power density.

In these experiments, it was found that an increase in intensity gave a corresponding increase in penetration for the treatable woods by using the Ceramic A Transducer. With these ceramic transducers, the treating time could be reduced to a matter of a few minutes at the high ultrasonic power density.

For treatable woods, the length of treating time is apparently critical for the shorter treating periods. Water-absorption tests for heart red gum (a wood difficult to treat) only indicated that ultrasonics may show promise for the treatment of heartwoods effectively.

References

1. The Dimensional Stabilization of Wood, First Progress Report, October 11, 1948, page 23.
2. The Dimensional Stabilization Program, Second Progress Report, December 2, 1949, page 1.
3. Application of Sonic and Ultrasonic Vibrations for Improvement of Wood, Third Progress Report, February 5, 1951, page 1.
4. Application of Sonic and Ultrasonic Vibrations for Improvement of Wood, Fourth Progress Report, February 8, 1952, page 1.

H. NON-DESTRUCTIVE TESTING OF WOOD

Objective

The objective of this program was to develop methods for determining the strength characteristics of wood without destroying the item being tested.

Summary

The dynamic modulus of elasticity of a standard-test-size wooden beam may be determined rapidly by non-destructive means. The moduli thus developed are within 10 percent of those determined by static bending tests.

By exciting the specimen with a sonic generator and recording the vibrations of the specimen, it is possible to determine the frequency of the fundamental resonance of the specimen. This fundamental frequency, in cycles per second, may be connected, on an alinement chart, with the weight of the specimen, in grams, to yield the dynamic modulus of elasticity of the specimen.

Both longtudinal and transverse vibration measurements can be made to determine the stiffness of wood.

A tentative method of studying strength properties of large structural timbers and beams was developed. This consisted of measuring the fundamental and the harmonic resonant frequencies of the member under test.

Investigations

Development and Basic Theory

It was believed that the treatability of wood could be improved by the low-frequency vibration since the natural resonant frequencies of boards and cuttings were well within the audible range. A series of tests was conducted to study the influence of size of specimen and density on frequency. Out of these tests evolved a non-destructive test method which can be used to determine the dynamic modulus of elasticity of wood.

The principle of the non-destructive test is relatively simple. It consists of vibrating a wood beam, either transversely or longitudinally, until the resonant frequency is obtained. The value of the frequency obtained, when substituted into the proper equation, along with the physical dimensions and density, gives the modulus of elasticity.

Essentially, the apparatus for wood testing consisted of a variable-frequency audio oscillator, electrodynamic vibrator, a crystal pickup, and a sensitive meter for recording the intensity of the vibration in the wood. For an accurate study, a cathode-ray oscilloscope was used with a voltage amplifier which magnified the signal voltage from the crystal pickup before the signal was fed into the oscillograph; further, a power amplifier was used between the vibrator and audio oscillator to increase the vibrational energy available for the vibrator.

In the literature on the vibration of isotropic materials, equations have been derived for beams in transverse and longitudinal vibration. Most of the printed equations for mechanical vibrations do not take into consideration shear deformation and the anisotropic property of wood. The accuracy of the uncorrected equation is, nevertheless, sufficient for most purposes and was employed as such in this study.

The basic relationships involving frequency, modulus and density were derived, and to equate these into an equation convenient for use, proportionality constants were determined whose values are derived from the size and shape of the wood beam, and the mode of vibration.

In tests on small beams, the fundamental frequency was sought rather than the harmonics. Where harmonics are involved, as in testing large beams, different constants are used.

The methods used for the non-destructive testing of small beams also apply to the vibration of large timbers with few modifications. The electronic equipment used was not capable of adequately detecting the lower resonant frequencies of long timbers and, therefore, the structural beams were vibrated at the higher harmonic frequencies which were more readily detected by the equipment.

The results obtained from the transverse vibration of 25 beams, representing 11 different kinds of wood, showed that the values found for resonant frequency agree closely with values computed mathematically. Also, it revealed that the higher density woods, such as hard maple, red oak, and white ash, all group themselves at the lower frequencies. On the other hand, the conifers, basswood, and yellow poplar fall in the higher frequency group; red gum, willow and one southern yellow pine occupy the intermediate positions.

The dynamic moduli generally was about 10 percent greater than the static, which was in good agreement with the data in the literature on wood. The longitudinal and transverse frequencies were in good agreement when related to the moduli as tested.

The study on large timbers (4 in by 5 in by 16 ft) indicated that it was possible to measure the frequencies to the fifth harmonic; however, the higher harmonics, when related back to the fundamental, were not as accurate as the lower ones. Using the fundamental, or the second or third harmonics, the dynamic modulus checked to within 10 percent of the static for the beam tested.

Non-Destructive Testing of Picker Sticks

Thirty-six hickory picker sticks, turned and ready for insertion into service, were tested non-destructively to determine their resonant frequency. All sticks were then placed singly in a Baldwin–Southwark Universal testing machine and loaded to 130 lb for the purpose of determining the slope of their load-over-deflector curve. Disregarding stick weight as being constant, it was found that those sticks with a high resonant frequency also produced a steep curve or possessed a higher degree of stiffness than those in which the resonant frequency was low.

The weight of the picker stick also appears to have some bearing on the resonant frequency. Since these tests were wholly preliminary, no attempt was made to correlate resonant frequency and weight ranges with actual values or allowable limits of stiffness.

References

1. The Dimensional Stability Program, Second Progress Report, December 2, 1949, page 35.
2. Application of Sonic and Ultrasonic Vibrations for Improvement of Wood, Third Progress Report, February 5, 1951, page 28.
3. Application of Sonic and Ultrasonic Vibrations for Improvement of Wood, Fourth Progress Report, February 8, 1952, page 17.

I. DIMENSIONAL STABILIZATION OF WOOD

Objective

It was the objective of this research program to develop economical and practical means of decreasing effectively the shrinking and swelling characteristics of lumber and other wood products, regardless of moisture changes in the surrounding medium.

Summary

In order to be effective, it was estimated that dimensional stabilization of wood products which are to be used under interior conditions must have an efficiency of 50 percent. Exterior items, such as sash and doors, must have a dimensional stability effectiveness of 60 percent. It was thought that treatment of the order of effectiveness of 75 percent was necessary to prevent the checking of lumber exposed to sun and rain.

Analyses were made of several items manufactured from wood to determine the in-service dimensional stability necessary to maintain acceptable tolerances in fitting at low moisture contents and freedom of moving parts at higher moisture contents. The products analyzed were sash, interior and exterior doors, and desks. Using data developed for various species of wood as to the percentage of tangential and radial swelling developed for each 1 percent rise in moisture content, and using standard construction

tolerances of moving wood parts, it was possible to determine the minimum degree of dimensional stabilization that was of practical value.

In tests to determine the degree of stabilization necessary to prevent checking of lumber exposed to rain and sunlight, it was found that checking still occurred despite the fact that the treatment of the lumber, through phenol formaldehyde impregnation, was 54 percent effective. It was further found, although water-repellent solutions were not as effective as phenol formaldehyde impregnation for dimensional stabilization, that the water-repellent sealer was more effective for the reduction of checking in wood exposed to sun and rain.

In the course of determining manufacturing tolerances for wooden desks, comparisons were made with steel desks of comparable price. It was found that steel desks were manufactured to closer tolerances than wooden desks of the same price field.

Investigations

Determination of Stabilization Requirements

Government and trade association literature, and specifications, were examined to determine what, if any, clearance tolerances were recommended for hardwood and softwood flooring, sash, and door installations. Also, theoretical analysis was made to determine the amount of stabilization necessary to control the movement of wood within the tolerances found in specifications and, as found in practice, to prevent the undesirable shrinking and swelling of wood in service. The findings are subject to many variations, but are entirely realistic.

Flooring

Any retarding of shrinkage or swelling of flooring would be helpful, but eliminating 50 to 75 percent of the movement of wood under varying conditions would, in the great majority of cases, guarantee a good job and a completely satisfied customer. Information as to factors that affect the suitability of wood floors before, during, and after installation have been widely publicized and may be summarized as follows:

1. Hardwood or softwood should be dried to the proper moisture content for installation.
2. Every effort should be made to keep the flooring at the recommended moisture content while in transit and while awaiting installation.
3. Flooring, at the proper moisture content, should be installed to a snug (but not tight) fit, over well-laid subfloor of proper moisture content.

Window Sash

Window sash and frame will either shrink or swell somewhat unless stabilized completely. The system of analysis used was theoretical and subject to variations. The study did indicate that reducing the amount of dimensional change in sash by 50 percent would probably eliminate most of the difficulties in connection with the shrinkage and swelling of window sash and frame.

Doors

The determination of the amount of dimensional stabilization necessary to permit close-fitting, year-round satisfactory operation of doors was calculated for standard-type Douglas fir and ponderosa pine doors. Standard sizes and recommended tolerances have been established by the National Door Manufacturers Association. Interior and

exterior doors are pre-fit to 3/16 in less in width and ⅛ in less in height than the nominal door size with a tolerance allowance of plus or minus 1/32 in.

There are many possible variables that enter into the fitting of doors and expansion or contraction of the doors with changing atmospheric conditions. However, as a general goal that would eliminate a great percentage of shrinking and swelling difficulties, it is felt that a 50 percent minimum reduction in the possible shrink or swell of wood in interior doors would be desirable, with 75 percent control as a goal for exterior doors.

Wood Desks

Desks were measured as they came off the factory production line in order to determine what clearance gaps were allowed between the moving drawers and the frame. From these data, an analysis was made to determine: (1) if the clearance gaps were adequate to prevent the drawers from sticking under humid summer conditions; (2) what degree of dimensional stability of sides, front, posts and rails would be theoretically necessary to prevent sticking of the drawers.

It was determined that desk drawers and framing fabricated at 6–8 percent moisture content should have a minimum of 50 percent of the wood expansion controlled and 75 percent, in many cases, would be satisfactory.

Comparison of Wood and Steel Desks

As a comparison to the data obtained from wood desks, steel desks on display at a retail office furniture store were measured in order to compare closeness of drawer fitting between metal and wood desks. Desks in the high, medium, and low-price brackets were measured to 1/1000 in for clearance between the drawers and frame.

The comparison of the average clearance gaps between drawers and frames of metal and wood desks indicates that the metal desks were fabricated to much closer tolerances than wood desks. On the basis of these studies, wood desk drawers and frames would need their shrinkage and swelling properties controlled by 50 to 80 percent to compete in closeness of fit and ease of movement with metal desk drawers and frames.

Structural Lumber

In general, shrinking and swelling of many structural wood items in roof trusses, bridges, etc., are considered to be of no importance. It is conceded, however, that the checking and splitting of such material is disadvantageous. Therefore, the required stabilization was determined through experiments aimed at learning how much stabilization would be required to practically eliminate all checking and splitting in structural material.

The treatment of wood with a water-repellent, sealer-type product will not stabilize wood over a long period of time against constant high humidities to the extent that phenol-formaldehyde resins will. However, the water-repellent dip treatments will retard shrinking and swelling somewhat, and will prevent checking of seasoned wood under outdoor conditions much more effectively than the phenol formaldehyde resin impregnations tested. Thus, the seemingly paradoxical situation is developed where a water-repellent, dip-type treatment tends to prevent checking of lumber exposed outdoors, although its permanent anti-swell or anti-shrink effect is less than phenol formaldehyde resin impregnations which do not prevent checking when treated lumber is exposed outdoors.

The tests on phenol formaldehyde impregnation of wood indicated that the shrinking

and swelling of wood would have to be retarded by a figure exceeding 54 percent control, and probably near 75 percent control of dimension changes, in order to prevent checking of southern yellow pine sapwood when exposed to rain and sunlight.

References

1. The Dimensional Stabilization of Wood, First Progress Report, October 11, 1948, page 1.

Advance Report of Committee 30—Impact and Bridge Stresses

D. W. Musser, *Chairman*

Summary of Tests on Steel Girder Spans

A. DIGEST

This is a summary of test results on 37 girder spans on which detailed reports have already been published in previous volumes of the AREA Proceedings (see Table 1, Column 13 of this report). Information pertinent to each span, including stress factors, ratio of top to bottom flange stresses, as well as the maximum value and average of the six highest values of roll effect, speed effect, track-and-hammer-blow effect, and total impact are tabulated on Tables 1 to 3.

Over 1100 values of roll effect for diesel locomotives and 1800 values for steam locomotives are plotted on Figs. 1 to 6. Also, 1800 diesel and 3400 steam locomotive total impact percentages are plotted on Figs. 7 to 12.

Total impact, considering the six highest recorded total impacts for each span, was compared with such factors as type of floor, span capacity, and type of substructure (see Figs. 13 to 15). Also, for some spans the run which produced the maximum total impact effect was compared with other runs of the same class of locomotive on the span which produced the maximum recorded values of each separate effect (see Figs. 16 and 17). The six highest values of roll effect for each span at girder centers are shown on Fig. 18.

From a study of these data a proposed revision of the design impact equation for girder spans was derived. The proposed equations are shown on Fig. 13. For other conclusions of this study see Sec. E of this report.

B. FOREWORD

Assignment 1 of Committee 30—Impact and Bridge Stresses, is Steel Girder Spans. Toward the fulfillment of this assignment, the AAR research staff conducted tests and secured data on 37 girder spans of various lengths, capacities and types of decks located on six railroads where diesel and steam locomotives are operated at high speeds. This is a summary of those tests. Reports on each of the spans have already been published and can be found in the Proceedings.

Testing was started in 1940 on the Pennsylvania Railroad and completed in 1952 with tests on the Milwaukee Road. Electromagnetic and SR–4 strain gages were used with oscillographs recording on photographic paper, and data were obtained from various elements of the structures. All of these oscillograms are at the AAR Research Center. A detailed description of the oscillograph, electromagnetic gages and auxiliary units is given in the AREA Proceedings, Vol. 46, 1945, page 201, and a description of the SR–4 wire resistance gages is given in the AREA Proceedings, Vol. 52, 1951, page 152.

The series of tests was conducted for AREA Committee 30 and was carried out under the general direction of G. M. Magee, director of engineering research, Engineering Division, AAR. The conduct of the tests, analysis of data, and preparation of the reports were under the direction of E. J. Ruble, research engineer structures, Engineering Division, AAR. This report was prepared by D. W. Wilkie, chief draftsman.

Test data are summarized in Tables 1, 2 and 3. In addition to these tables, there

are presented two charts showing maximum impacts, six figures showing roll effects, six figures on total impacts, and three figures showing the effect of certain variables on total impact.

C. TEST SPANS

Table 1 shows the general data for the 37 spans tested. Col. 1 shows the identification number used for each span throughout the report. This column also appears on the next two tables. In Col. 2 are found the names of the railroads operating over the spans. The year of erection of the spans and the year in which any material changes were made in them are given in Col. 3. The girder spans are listed in the order of their lengths as shown in Col. 4. Col. 5 indicates the center-to-center distance between bearings.

It can be seen from Col. 6 that there are 28 deck girder spans and 9 through girder spans. Col. 7 indicates the type of floor, 5 spans being ballasted concrete, 13 spans ballasted timber, 16 open timber and 3 ballasted wrought iron. Concrete is the main substructure of the spans, as shown in Col. 8.

The distance center to center of girders (Col. 9) varied from 5 ft to 19 ft 2 in.

There were two girders per track for each of the spans (Col. 10). The depth ratio of the girders vary from 1/7.8 to 1/12.9 and the stiffness factor from 73 in^3 to 785 in^3 (Cols. 11 and 12, respectively.) No composite action was considered.

Col. 13 indicates the location of data in the AREA Proceedings.

D. TEST RESULTS

1. Dead-Load and Live-Load Stress

Table 2, Col. 1, indicates the span number. The dead-load stress (Col. 14) was found to vary from 1.09 to 7.40 ksi. The capacity of each span, in terms of Cooper E loading, is shown in Col. 15. The capacity is based on the present AREA allowable design stresses and steam–locomotive impacts, computed on the gross section of the steel.

The rating of both diesel and steam locomotives, as shown in Cols. 16 and 17, is in terms of Cooper loading for moment at the center of span. The ratings for the diesels ranged from E 21.0 for an articulated locomotive to E 51.3. The ratings for the steam locomotives ranged from E 54.7 to E 70.5.

In these tests, strains in various elements of the structures were measured during a series of runs with a test train operating at a complete range of speeds. Runs were also secured under regularly scheduled trains operating in some instances at controlled speeds. The axle loads and a general description of the locomotives used may be found in the above-cited detailed reports.

The stress factor for any test run is the ratio of the recorded static stress to the calculated static stress for the locomotive used. The calculated static stress is determined for the exact position of the locomotive wheels which produced the maximum recorded static stress. It is computed on the basis of concentrated wheel loads, the gross moment of inertia of the girder for moment and gross area of the web for shear.

The recorded static stress is the average of the greatest mean simultaneous stresses in the two girders during slow-speed runs of each locomotive. The average stress factors are shown in Cols. 18 to 21. The stress factors for bending varied as follows: for the diesel locomotives, 0.70 to 1.14; for the steam locomotives, 0.66 to 1.08. The averages of all bending-stress factors for diesel and steam locomotives were 0.89 and 0.87, respec-

tively. The stress factor for shear varied as follows: for the diesel locomotives, 0.58 to 1.39; for the steam, 0.69 to 1.32. The averages of all shear stress factors for diesel and steam locomotives were 0.87 and 0.88, respectively. Generally, the shorter spans had lower stress factors than the longer spans.

The average static bending stress was measured simultaneously at the top and bottom flanges of some of the girder spans and is shown in Cols. 22 to 25. The ratio of the top to bottom flange stress is shown in Cols. 26 and 27.

Col. 28 shows whether the deck is so constructed that it might interact with the flanges in carrying flange stress. The ratios in Cols. 26 and 27 indicate that such interaction actually occurred in some instances.

It should be pointed out that expansion bearings which have become partially or totally inoperative may cause a redistribution of stress, resulting in higher compressive stresses in the top flange and lower tensile stresses in the bottom flange. This may exaggerate or completely obscure the effect of interaction of the deck with the flanges.

2. Dynamic Effects

Table 3 is a summary of the various effects which contribute to total dynamic effect, or impact as it is commonly called. These are roll effect, speed effect and track- and hammer-blow effect. For each effect the maximum value recorded for each span under both diesel and steam locomotives is shown, and the average of the six highest recorded values for each span is also shown. Impact effects are expressed in percent of average recorded static stress.

3. Roll Effect

Roll effect is an increase in the mean stress in one girder with a corresponding simultaneous decrease in the mean stress in the other girder of the same span during the passage of a locomotive. Since the roll effects were measured at the girders, these values are shown in Cols. 29 and 32, but since the AREA specifications require a roll effect equal to 20 percent at the rail centers, computed equivalent values at rail centers are also shown in Cols. 30, 31, 33 and 34 for comparison.

The maximum recorded values based on rail centers for the diesels ranged from 3.2 to 44.9 percent, and the average of all the maximum values is 14.5. The values for steam locomotives ranged from 2.8 to 38.2, the average being 16.2.

Figs. 1 to 6 show the values of roll effect from all the reports, based on rail centers, in percent of recorded static stress versus speed. Some 1100 values for diesel and 1800 values for steam locomotives are plotted on three figures each for diesel and steam locomotives. They are classified according to the lengths of the spans: 40 to 60 ft, 60 to 90 ft, and 90 to 140 ft. A further breakdown of the roll effects with respect to open-floor and ballasted-floor spans is also shown. Fig. 18 shows a comparison of roll effect as actually recorded at the girders.

4. Speed Effect

Speed effect is the increase in the average of the mean simultaneous stresses recorded in the girders resulting from the locomotive crossing the span at various speeds over the static or slow speed. The term "speed effect" is used because it frequently appears to increase with an increase in speed.

Among the various factors which cause this speed effect are the following: (1) the centrifugal force resulting from the loaded axles running over the deflected span; (2) the vertical oscillation of the sprung weight of the locomotive; (3) the acceleration of the unsprung weight of the locomotive during the oscillation of the sprung weight;

(4) variations in the top-of-rail profile from a straight line, which may result in a vertical curve in the track (not to be confused with the track effect due to rail joints or other localized track irregularities); (5) variations in the dead-load weight of the locomotives, such as may be due to fuel and water consumption, or minor repairs or alterations; and (6) other effects which may not as yet have been recognized.

The measured maximum speed effects in percent of measured static stresses and the average of the six highest are found in Table 3, Cols. 35 to 38, incl. The highest value for the diesel locomotives is 39.4 and for the steam, 62.4. The average of the highest values of speed effect for the diesel and steam locomotives is 15.8 to 16.3, respectively.

5. Track- and Hammer-Blow Effect

Track effect is the stress due to the vertical vibration induced in a railroad bridge during the passage of a locomotive, by wheel and track irregularities. This occurs with both diesel and steam engines. Hammer-blow effect is a periodic disturbing force brought about by the centrifugal force of the unbalanced counterweights on the revolving drive wheels of steam locomotives. In the data for the steam engines these two effects could not be separated.

The maximum track-plus-hammer-blow effects and the average of the six highest values are tabulated for each of the spans; they can be found in Cols. 39 to 42, incl. The highest value for diesel and steam locomotives is 35.3 and 50.0, respectively. The average of maximum values is 15.0 for diesel and 28.7 for steam locomotives.

6. Total Impacts

The total impact for each test run for a particular speed is the increase in stress in a member over the average mean stress occurring at a slow speed for the same locomotive class. As mentioned previously, the total impacts are the combination of (1) roll effect, (2) speed effect, and (3) track- and hammer-blow effects. It is highly improbable that the maximum for all effects would occur simultaneously. The maximum recorded total impact for diesel locomotives was 64.8 and for steam, 77.1. The average of the six highest values per span for the diesels ranged from 5.3 to 41.7 and for the steam locomotives from 14.3 to 50.0 (see Table 3, Cols. 43 to 46, incl.).

The total impact percentages resulting from 1800 diesel values and 3400 steam-locomotive values are shown on Figs. 7 to 12, incl. Also shown on the diagrams are the computed impact percentages based on the AREA design specification for rolling equipment without hammer blow in the case of diesel locomotives, and for rolling equipment with hammer blow in the case of steam locomotives. It should be noted that the design impact percentages are plotted for average conditions, but that the actual design percentage for each span may vary considerably.

In addition to the values from these 37 test spans, values from the DT&I Railroad Bridge Test, Vol. 50, 1949, are also included.

It can be seen that almost all of the points are below the specification impact allowance.

The last column of Table 3 indicates whether the maximum recorded total impact occurred during a run at or near the synchronous speed. It can be seen that the maximum recorded total impacts did not necessarily occur at the synchronous speed as determined by the calculated natural loaded frequency of the spans.

7. Comparison of Total Impacts

For a comparison of total impact with respect to type of floor, span capacity and type of substructure, see Figs. 13 to 15, incl. Each figure has the six highest values

of impact for each span plotted for diesel and steam locomotives. A vertical line is drawn through each of the values, and the attached circle gives the identification number of the span involved. A horizontal line at each span shows the present AREA design impact value for that span.

Fig. 13 shows the effect of type of floor on the total impact. For diesel locomotives the total recorded impacts in ballasted-floor bridges were lower than the total calculated impacts. This was also true for steam locomotives with the exception of values from one run on span 1 and one run on span 35.

The total impacts were generally higher with steam locomotives than with diesels, although the reverse was true for spans 4, 11, 12, 29 and 34.

The total impacts decreased with an increase in span length.

Fig. 14 shows the effect of design capacity on total impact. During the preparation of some of the earlier detailed reports on girder spans it appeared that with low live-load unit stresses the impact percentages were generally higher than with greater live-load unit stresses. Fig. 14 generally confirms this, with the exception of span 10.

Fig. 15 compares the total impacts on the basis of type of substructure. There were three types of substructure—concrete piers, steel towers, and stone piers—and the values are plotted as before. The type of substructure does not appear to have any significant effect.

8. Runs Producing Maximum Total Impact

As mentioned previously, the total impact is composed of (1) roll effect, (2) speed effect, and (3) track-and-hammer-blow effect. Figs. 16 and 17 show in the form of bar graphs how the magnitude of the separate maximum effects compare with the maximum total impact for some of the spans. Certain runs which produced high impacts were selected, and the total impacts were plotted, together with the simultaneous values of each effect that made up that total impact. Also plotted were the maximum recorded values of each effect for other runs of the same class locomotive on the span involved.

The graphs indicate that if the maximum values of the separate effects could have occurred simultaneously, the resulting total impact would be greater than that actually recorded.

In Fig. 17 it can be seen the maximum total impact occurred at speeds below the synchronous speeds, except on spans 7, 17, 25 and 26.

9. Additional Considerations

In addition to the test results already summarized, the testing of the spans afforded studies with regard to other design considerations, as follows:

a. Maximum Stresses in Girders

The maximum live-load-plus-impact stresses recorded in the lower flanges close to the center of the girders of all the spans tested were determined. The maximum live-load-plus-impact stresses were also determined in the web of the girder at the ¼ point and at end of the span, with the exception of those spans tested on the Pennsylvania Railroad. For the Burlington test the maximum recorded stresses at the end were reported.

b. Maximum Stresses in Lateral Bracing

The maximum direct stresses recorded in the lateral bracing angles were determined by placing the gages close to the neutral axis of the angles. This information is reported in the IC, CB&Q, CMStP&P and C&NW tests.

c. Frequency of Maximum Stresses

This is based on the frequency of occurrence of the maxiumum stresses on the span tested since the strain gage readings were secured under regular trains with the speed reduced on only a few of the trains for slow-speed runs. In the following tests information on the frequency of maximum stresses can be found: the IC, CB&Q, CMStP&P and C&NW.

d. Stresses at the Ends of the Cover Plate

On several CB&Q and CMStP&P spans the stresses in cover plates at several locations near the end of the cover plate were determined by SR–4 strain gages.

e. Shape of the Moment Curve

The shape of the moment curve under normal high-speed loading was determined for spans 1 and 2 on the IC.

f. Stresses at The Web Splice

Recorded stresses in the lower flanges on a section through a web splice and outside the splice were determined on span 15 of the CB&Q test bridge.

g. Transverse Bending of Flanges

For variation of stress across the flange, gages were placed at the center and outside edges of the flange of some spans in the IC, CB&Q, CMStP&P and C&NW test bridges.

h. Strain Rosette on Girders

A comparison was made between the maximum stresses on the girder webs found by a single gage at 45 deg and the principal stresses in the webs found by rosette strain gages, which were used on spans 3, 11 and 30 of the CMStP&P test bridge.

E. CONCLUSIONS

1. Roll Effect

One of the most significant conclusions that can be drawn from these tests is that the present method of providing for impact due to rolling effect in the AREA design specifications could not been substantiated.

First, a study of Figs. 1 to 6 shows that the present design requirement for roll-effect impact does not agree very well with recorded values. It should be noted that the recorded values have been adjusted to equivalent values at rail centers. As a result of this study, the six highest values for each span were replotted on Fig. 18 as actually recorded at the girder centers. An envelope curve on this figure more accurately describes the recorded roll-effect impact.

Second, a study of Figs. 16 and 17 shows that the roll effect generally is small when the other impact effects are at or near a maximum. This does not agree with the present design requirement for simultaneous maximums.

2. Effect of Ballasted Floor

Another significant conclusion is that bridges with ballast floors have definitely lower recorded total impact values. This shows most clearly on Fig. 13.

3. Higher Impacts for Longer Spans

Fig. 13 indicates that the longer spans may have higher impacts than is provided by the present design equation. Of the 15 values on Fig. 13 which exceed the present design equation, 10 occur on spans 29, 35 and 37, which are the longer spans.

4. Proposed New Impact Equations

As an illustration of how these conclusions might be of benefit to the railroads, a proposed revision of the design impact equation for girder spans has been shown on Fig. 13. This proposed equation should be modified for rating purposes at slower speeds. The advantages of the proposed equation are as follows:

a. It would include roll effect and direct vertical effect in one equation. In addition to being more accurate, it would be simpler in application.

b. It would reflect the advantages of ballasted floors.

c. It would provide for higher impacts for the longer spans.

d. It would serve both economy and safety, since it provides for lower design impact values for most spans, yet requires higher values for some.

5. Other Conclusions

This series of tests substantiates that total impacts reduce with increased span length, with diesels and with reduced speed. Also, from the special studies made during this series of tests—namely, studies of (a) maximum stresses in girders, (b) maximum stresses in lateral bracing, (c) frequency of maximum stresses, (d) stresses at ends of cover plates, (e) shape of moment curve, (f) stresses at web splices, (g) transverse bending of flanges, and (h) strain rosette on girders (see pages 55–56)—other conclusions can be drawn which may be fully as important as those given above in that they generally verify the validity of most of the design assumptions for girder spans in the AREA design specifications.

TABLE 1. TEST SPANS

SUMMARY OF TEST DATA ON GIRDER SPANS

Test Span Number	Railroad	(a) Year Erected	Length	Span C-C Bearings	Type of Girder	Type of Floor	Type of Sub-Structure	C-C of Girders	Number of Girders Per Track	Depth Ratio	$\frac{I}{L}$ Per Rail, in.^{3}	Location of Data in Proceedings
Col. 1	2	3	4	5	6	7	8	9	10	11	12	13
1	IC	1921	40'-0 SB	38'-2 1/2	Deck	Ballasted Concrete	Concrete	7'-0	2	1/10.6	73	Vol. 53, 1952, p. 147
2	IC	1921	40'-0 NB	38'-2 1/2	Deck	Ballasted Concrete	Concrete	7'-0	2	1/10.6	73	Vol. 53, 1952, p. 147
3	CMStP&P	1930	40'-0 EB	39'-0	Deck	Open Timber	Concrete	7'-6	2	1/7.8	117	Vol. 57, 1956, p. 15
4	CMStP&P	1930	40'-0 WB	39'-0	Deck	Open Timber	Concrete	7'-6	2	1/7.8	117	Vol. 57, 1956, p. 15
5	CMStP&P	1913 (1945)	46'-8 3/4	45'-8 3/4	Deck	Ballasted Timber	Concrete	8'-0	2	1/8.2	119	Vol. 57, 1956, p. 15
6	AT&SF	1906 (1945)	48'-0 EB	46'-3	Deck	Ballasted Timber	Concrete	7'-0 1/2	2	1/8.4	114	Vol. 58, 1957, p. 85
7	AT&SF	1898 (1945)	48'-0 WB	46'-3	Deck	Ballasted Timber	Stone	7'-0 1/2	2	1/8.7	114	Vol. 58, 1957, p. 85
8	CB&Q	1899 (1932, '43, '44)	49'-11 1/2	48'-6	Through	Open Timber	Concrete	11'-11 7/16	2	1/9.7	86.2	Vol. 59, 1958, p. 1
9	CB&Q	1904 (1941, '44)	50'-0	48'-9	Deck	Ballasted Timber	Concrete	7'-0	2	1/7.8	199	Vol. 59, 1958, p. 1
10	PRR	1903	55'-10	54'-0	Deck	Open Timber	Stone	5'-0	2	1/10.5	104	Vol. 42, 1941, p. 393
11	CMStP&P	1930	55'-0 EB	54'-0	Deck	Open Timber	Concrete	7'-6	2	1/8.8	174	Vol. 57, 1956, p. 15
12	CMStP&P	1930	55'-0 WB	54'-0	Deck	Open Timber	Concrete	7'-6	2	1/8.8	174	Vol. 57, 1956, p. 15
13	IC	1901	60'-0 NB	58'-9	Deck	Open Timber	Concrete	8'-0	2	1/8.8	162	Vol. 53, 1952, p. 147
14	IC	1925	60'-0 SB	58'-4	Deck	Open Timber	Concrete	7'-0	2	1/8.8	198	Vol. 53, 1952, p. 147
15	CB&Q	1936	60'-0	58'-4	Through	Ballasted Iron	Concrete	17'-6	2	1/8.8	197	Vol. 59, 1958, p. 133
16	CB&Q	1904 (1941, '46)	65'-0	63'-9	Deck	Ballasted Timber	Concrete	7'-0	2	1/9.4	239	Vol. 59, 1958, p. 1
17	AT&SF	1906 (1931)	70'-0 EB	68'-6	Deck	Ballasted Timber	Concrete	6'-10 1/4	2	1/12.9	135	Vol. 58, 1957, p. 85
18	AT&SF	1906 (1931)	70'-0 WB	68'-6	Deck	Ballasted Timber	Concrete	6'-10 1/4	2	1/12.9	135	Vol. 58, 1957, p. 85
19	C&NW	1929	70'-0 1/4 EB	68'-5 1/4	Deck	Open Timber	Steel	8'-0	2	1/8.9	328	Vol. 52, 1951, p. 1
20	C&NW	1929	70'-0 1/4 WB	68'-5 1/4	Deck	Open Timber	Steel	8'-0	2	1/8.9	328	Vol. 52, 1951, p. 1
21	C&NW	1905	71'-10 EB	70'-10	Deck	Open Timber	Stone	6'-6	2	1/10.5	165	Vol. 52, 1951, p. 1
22	C&NW	1905	71'-10 WB	70'-10	Deck	Open Timber	Stone	6'-6	2	1/10.5	165	Vol. 52, 1951, p. 1
23	CB&Q	1936	75'-0	73'-4	Through	Ballasted Iron	Concrete	17'-6	2	1/9.4	279	Vol. 59, 1958, p. 1
24	C&NW	1916	78'-0 EB	77'-0	Deck	Ballasted Concrete	Stone	8'-0	2	1/9.5	256	Vol. 52, 1951, p. 1
25	C&NW	1916	78'-0 WB	77'-0	Deck	Ballasted Concrete	Stone	8'-0	2	1/9.5	256	Vol. 52, 1951, p. 1
26	PRR	1933	82'-11	81'-0	Deck	Ballasted Concrete	Concrete	7'-0	2	1/9.04	396	Vol. 45, 1944, p. 47
27	CMStP&P	1941	85'-0	83'-6	Through	Ballasted Timber	Steel Pile	16'-5	2	1/9.4	336	Vol. 57, 1956, p. 15
28	CB&Q	1902 (1943, '46)	85'-0	83'-6	Deck	Ballasted Timber	Concrete	7'-0	2	1/9.4	388	Vol. 59, 1958, p. 1
29	CB&Q	1904 (1941, '44)	90'-0	88'-0	Through	Open Timber	Concrete	15'-8	2	1/9.9	398	Vol. 59, 1958, p. 1
30	CMStP&P	1947	94'-10	92'-6	Deck	Open Timber	Concrete	8'-0	2	1/10.5	378	Vol. 57, 1956, p. 15
31	AT&SF	1903 (1944)	100'-0	97'-8	Deck	Ballasted Timber	Concrete	10'-0	2	1/10.5	333	Vol. 58, 1957, p. 85
32	CB&Q	1936	100'-0	98'-4	Through	Ballasted Iron	Concrete	17'-6	2	1/10.9	400	Vol. 59, 1958, p. 1
33	CB&Q	1905	102'-0	100'-0	Deck	Ballasted Timber	Concrete	7'-0	2	1/9.6	520	Vol. 59, 1958, p. 1
34	CMStP&P	1934	107'-0	105'-0	Through	Ballasted Timber	Concrete	17'-6	2	1/10.1	500	Vol. 57, 1956, p. 15
35	CMStP&P	1945	110'-2	108'-0	Through	Ballasted Timber	Concrete	19'-2	2	1/10.4	530	Vol. 57, 1956, p. 15
36	PRR	1903	122'-0	119'-0	Deck	Open Timber	Stone	8'-0	2	1/11.75	488	Vol. 42, 1941, p. 393
37	CMStP&P	1946	140'-0	137'-6	Through	Open Timber	Steel Pile	19'-0	2	1/11.0	785	Vol. 57, 1956, p. 15

(a) Dates shown thus ( ) indicate year altered.

TABLE 2. DEAD LOAD AND LIVE LOAD DATA

SUMMARY OF TEST DATA ON GIRDER SPANS

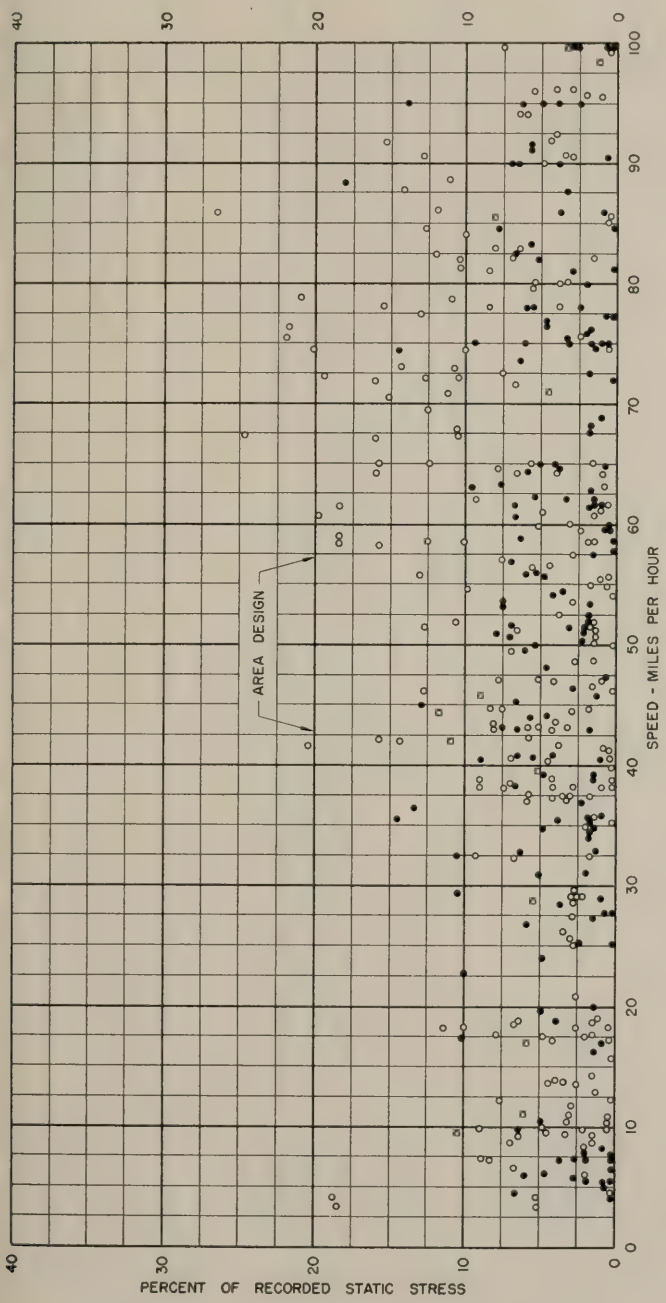
Test Span Number	Dead Load Stress (ksi)	(a) Capacity at Design Stress	Rating of Maximum Locomotive		Static				Dynamic						
					Average Stress Factor				Average Stress in Flanges at Center-ksi				Ratio of Avg. Top and Bottom Flange Stress		Possible Interaction With Flanges
					Bending at Center		Shear at End		Top		Bottom				
			Diesel	Steam	Diesel	Steam	Diesel	Steam	Diesel	Steam	Diesel	Steam	Diesel	Steam	
Col. 1	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	3.58	E74.8	E36.8	E67.8		0.67		0.84	-2.13	-4.27	+3.24	+5.98	0.66	0.71	Yes
2	3.58	E74.8	E36.8	E67.8	0.70	0.66	0.79	0.69	-2.49	-4.21	+3.31	+5.30	0.75	0.79	Yes
3	1.54	E98.5	E40.1	E63.8	0.80	0.77	0.78	0.75							No
4	1.54	E98.5	E40.1	E63.8	0.72	0.76	0.58	0.74							No
5	4.74	E74.8		E64.3		0.85		0.88							No
6	2.30	E71.5	E40.2	E61.1	0.72	0.78	0.75	0.85							No
7	2.30	E71.5	E40.2	E61.1	0.76	0.74	0.80	0.82							No
8	1.58	E61.9	E21.0	E54.7	1.03	0.93	0.75	0.69		-9.14		+7.61		1.20	Yes
9	1.72	E108.8	E39.9	E66.2	0.85	0.87									No
10	1.31	E50.0	E51.3	E60.4	0.98	0.96			-7.80	-9.23	+8.65	+10.35	0.90	0.89	No
11	2.07	E96.6	E40.9	E67.8	0.76	0.83	0.90	0.87							No
12	2.07	E96.6	E40.9	E67.8	0.76	0.83	0.81	0.85							No
13	1.24	E80.2	E39.8	E65.7	0.91	0.75	0.97	1.03	-5.61	-8.45	+4.25	+6.55	1.32	1.29	No
14	1.09	E97.2	E39.8	E65.7	0.87	0.82	0.95	1.08	-3.99	-6.57	+3.83	+6.10	1.04	1.08	No
15	1.94	E95.0	E40.8	E67.0	0.99	0.98	0.84	0.87	-4.57	-7.36	+4.68	+7.57	0.98	0.98	No
16	2.22	E99.2	E41.1	E66.5	0.88	0.93	0.78	0.78							No
17	3.32	E62.6	E40.9	E60.6	0.87	0.89	0.88	0.94							No
18	3.32	E62.6	E40.9	E60.6	0.77	0.81	0.86	0.94							No
19	1.20	E125.0	E38.8	E63.6		0.89		1.21							No
20	1.20	E125.0	E38.8	E63.6	1.09	1.08	1.28	1.10							No
21	1.52	E75.3	E38.4	E65.3	1.14	0.98	1.39	1.32	-6.34	-9.63	+5.44	+8.46	1.17	1.14	No
22	1.52	E75.3	E38.4	E65.3	1.05	0.96	0.99	1.08							No
23	2.16	E95.9	E40.2	E65.0	0.97	0.95	0.86	0.73	-4.57	-7.29	+4.52	+7.02	1.01	1.04	Yes
24	5.00	E66.3	E39.6	E65.9	0.93	0.85	0.87	0.84	-4.09	-6.67	+4.11	+6.60	0.99	1.01	Yes
25	5.00	E66.3	E39.6	E65.9		0.84		0.86							Yes
26	2.84	E93	E49.0	E60.0	0.91	0.90									Yes
27	5.36	E91.5	E35.7	E61.4	0.74	0.75	0.79	0.74	-3.79	-6.59	+3.13	+5.31	1.21	1.24	Yes
28	2.50	E101.0	E39.5	E70.5	0.81	0.83	0.67	0.80							No
29	1.97	E108.8	E39.7	E70.0	1.02	0.99	0.75	0.79	-4.51		+3.74		1.20		Yes
30	3.51	E98.9	E40.2	E65.0	0.98	0.88	0.99	0.85	-4.05	-6.12	+4.09	+6.59	0.99	0.93	No
31	3.40	E72.4	E41.8	E69.5	0.98	0.97	0.77	0.88							No
32	2.73	E97.0	E40.2	E65.1	1.00	0.97		0.76	-4.92	-7.99	+4.49	+7.16	1.09	1.11	Yes
33	2.80	E102.0	E40.2	E68.7	1.01	0.97	0.89	0.94							No
34	6.87	E96.7	E36.4	E65.5	0.88	0.85		0.81	-3.54	-6.16	+3.37	+6.01	1.05	1.02	Yes
35	7.40	E99.5		E65.0		1.04		0.94							Yes
36	2.28	E64.0	E41.7	E55.9	0.82	0.80			-4.48	-6.02	+5.31	+6.41	0.84	0.94	No
37	6.36	E106.0	E36.7	E62.8	0.90	0.81		0.86	-3.44	-5.48	+3.39	+5.02	1.01	1.09	Yes

(a) Based on steam impacts and gross section.

TABLE 3. DYNAMIC EFFECTS

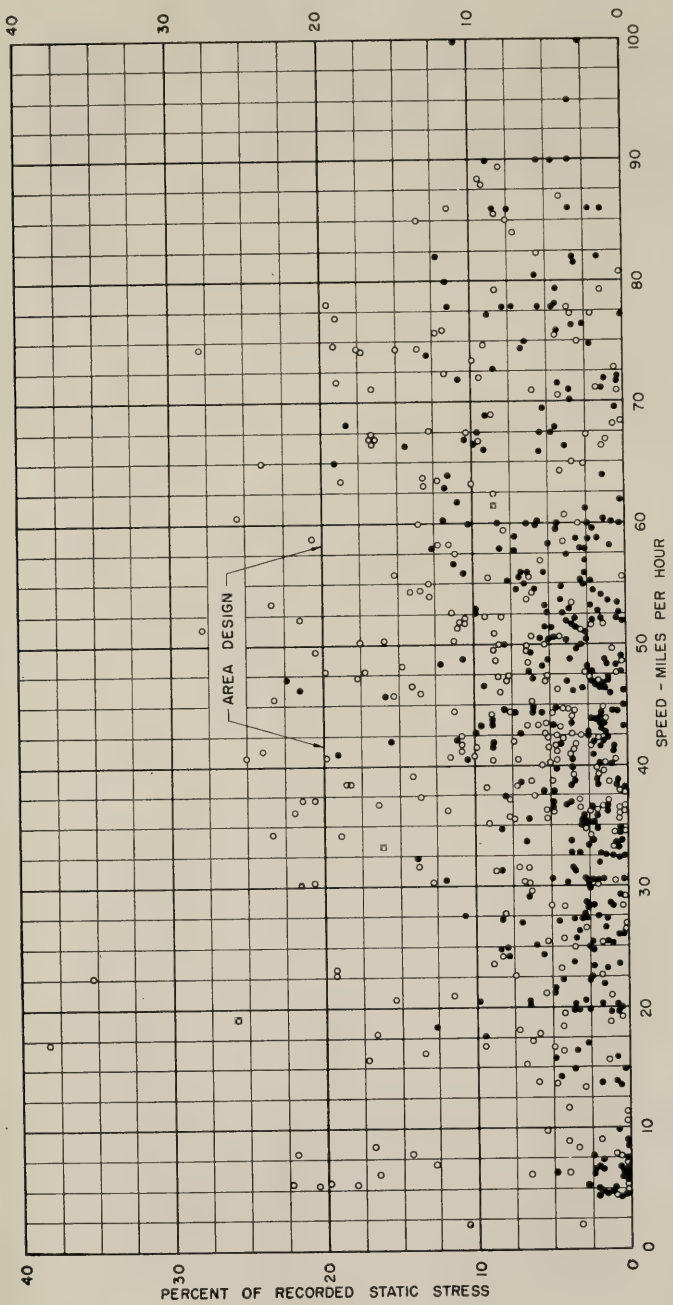
SUMMARY OF TEST DATA ON GIRDER SPANS

Test Span Number	Roll Effect - %						Speed Effect - %				Track and Hammer Blow - %				Total Impact - %				Recorded at Synchronous Speed
	Diesel			Steam			Diesel		Steam		Diesel		Steam		Diesel		Steam		
	Max Rec at Gird	At Rail Centers Max Rec	At Rail Centers Avg 6 High	Max Rec at Gird	At Rail Centers Max Rec	At Rail Centers Avg 6 High	Max Rec	Avg 6 High	Max Rec	Avg 6 High	Max Rec	Avg 6 High	Max Rec	Avg 6 High	Max Rec	Avg 6 High	Max Rec	Avg 6 High	
Col. 1	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
1	9.9	13.9	10.1	9.2	12.9	11.2	15.7	11.7	34.5	21.0	20.4	16.1	50.0	43.3	31.8	23.2	74.9	40.6	No
2	6.6	9.3	7.4	16.0	22.4	15.9	7.4	4.9	28.0	21.0	20.1	17.0	39.1	34.1	25.0	19.2	59.3	34.3	No
3	14.7	22.0	18.9	25.4	38.2	29.5	39.4	26.8	62.4	44.3	35.3	20.3	21.4	17.5	64.8	33.0	77.1	50.0	No
4	13.7	20.5	12.8	16.8	25.2	22.9	22.8	20.7	20.3	15.7	30.6	26.5	25.8	17.8	57.6	41.7	43.3	25.7	No
5				13.6	21.8	11.9			24.9	12.7			30.5	28.4			48.3	28.3	No
6	9.2	12.9	9.6	16.3	23.0	15.1	19.4	8.6	16.7	9.6	15.9	15.9	18.0	15.3	30.3	19.2	43.0	20.5	No
7	4.5	6.3	5.4	10.3	14.4	11.7	17.0	8.0	33.2	25.8	18.1	15.0	37.0	28.1	33.5	17.0	50.0	37.1	Yes
8	6.6	15.1	9.3	3.7	8.6	8.0			15.1	11.8	17.3	12.8	34.2	30.8	24.0	14.3	42.6	35.6	No
9	5.1	7.2	6.0	7.9	11.1	8.1	8.6	6.6	7.8	5.7	10.3	9.1	20.6	16.3	21.9	16.5	32.3	17.5	No
10	26.6	26.6	22.5	15.8	15.8	14.3	19.8	17.5	16.7	14.8	16.1	15.5	40.2	36.6	55.0	34.7	67.5	35.4	No
11	13.4	20.1	11.9	11.7	17.6	9.2	20.8	17.7	25.7	21.4	25.8	17.2	8.9	8.2	46.1	26.1	41.9	27.5	No
12	9.5	14.3	10.8	13.8	20.7	19.8	17.9	13.9	20.3	14.5	20.5	17.1	13.2	9.8	45.9	27.6	40.1	22.4	No
13	7.0	11.2	9.1	13.5	21.6	20.0	2.3	1.5	26.6	19.1	11.5	9.0	43.1	33.4	19.0	8.4	63.8	43.6	No
14	11.2	15.8	13.6	11.7	16.3	12.4	4.4	3.4	22.1	20.3	21.6	15.6	31.7	29.6	26.1	21.0	47.1	30.5	No
15	5.2	18.2	10.6	3.8	13.3	11.1	18.2	8.2	12.7	7.3	15.3	12.6	16.9	14.2	22.4	16.6	31.3	22.4	Yes
16	5.9	8.2	5.5	6.0	8.4	6.6	9.0	7.2	8.9	4.4	10.0	7.7	28.1	20.4	15.0	12.3	32.0	18.1	No
17	9.2	12.6	9.5	7.3	9.9	7.3	16.1	12.8	20.9	11.0	15.8	14.7	27.0	22.6	31.6	27.3	47.3	21.2	Yes
18	8.3	11.3	7.2	4.6	6.3	4.1	19.1	14.0	11.4	8.3	19.0	16.7	27.6	25.8	32.5	22.5	36.4	23.4	Yes
19	3.1	5.0	3.2	11.8	18.9	11.7	5.5	4.5	14.6	7.3	17.1	13.2	50.0	41.3	20.0	12.0	62.1	23.3	No
20	9.6	15.4	10.9	12.7	20.4	18.0	34.2	12.4	14.8	10.8	13.0	11.5	33.8	30.1	41.9	15.2	50.6	23.2	No
21	11.2	14.5	7.0	10.7	13.9	9.0	14.5	7.4	14.1	10.0	12.5	10.5	43.3	35.8	24.9	12.7	46.4	26.6	No
22	10.7	13.9	11.2	10.9	14.2	12.6	22.2	12.0	20.2	13.8	10.7	10.6	35.4	31.4	31.6	15.4	50.2	26.6	No
23	3.3	11.5	9.9	9.0	31.5	23.0	15.0	13.2	16.0	6.3	8.9	7.3	18.2	13.5	29.0	19.7	31.1	20.1	Yes
24	9.4	15.0	10.9	6.6	10.3	8.3	17.1	9.3	15.4	10.4	8.3	7.1	38.1	34.8	27.3	11.9	50.2	29.4	No
25	6.0	9.6	4.7	8.2	13.1	10.5	4.3	3.4	18.5	12.5	8.0	7.4	48.4	36.9	18.4	7.9	48.7	29.0	Yes
26	4.3	6.0	5.3	7.8	10.9	7.4	5.3	4.2	6.3	5.2	10.5	8.9	33.6	33.0	15.0	9.4	41.5	27.7	Yes
27	4.2	13.8	10.5	4.4	14.5	12.8	21.6	15.1	12.2	8.3	14.0	11.5	34.0	30.7	27.4	16.7	37.3	24.7	No
28	5.9	8.3	4.6	4.8	6.7	4.2	17.7	12.6	14.3	11.4	9.2	8.1	27.6	21.0	28.5	21.6	46.9	23.0	No
29	11.7	36.6	29.2	4.5	14.5	12.3	16.8	15.1	15.9	9.4	14.8	13.9	16.4	14.2	41.1	29.3	28.1	19.8	Yes
30	4.2	6.7	6.2	5.2	8.3	4.8	15.0	12.0	14.8	9.8	8.8	7.0	8.4	7.8	22.8	17.1	23.5	14.3	No
31	3.5	6.9	6.2	4.4	8.8	7.0	5.5	1.8	10.8	8.3	11.9	8.8	24.3	19.1	12.1	7.5	27.1	21.6	Yes
32	1.9	6.7	6.1	2.7	9.5	6.7	18.4	11.7	13.0	8.0	9.3	6.4	16.0	13.1	18.3	13.2	27.0	19.6	Yes
33	2.3	3.2	2.0	2.0	2.8	2.3	1.0	0.9	5.8	3.7	7.5	4.9	14.3	13.3	6.6	5.3	21.2	18.0	No
34	12.8	44.9	29.9	6.4	22.4	16.6	24.6	15.8	10.6	10.1	19.3	14.9	6.8	5.2	23.8	19.7	20.9	14.5	No
35				5.9	22.6	21.0			10.8	9.0			40.5	33.2			46.4	25.8	No
36	10.2	16.3	14.9	8.1	13.0	9.3	12.5	9.8	13.0	11.4	9.2	7.8	18.9	18.0	26.6	16.4	32.3	27.4	Yes
37	8.7	33.0	24.9	9.6	36.3	28.1	26.5	15.5	27.1	17.2	6.9	4.7	39.5	33.9	29.3	23.2	44.9	23.0	No



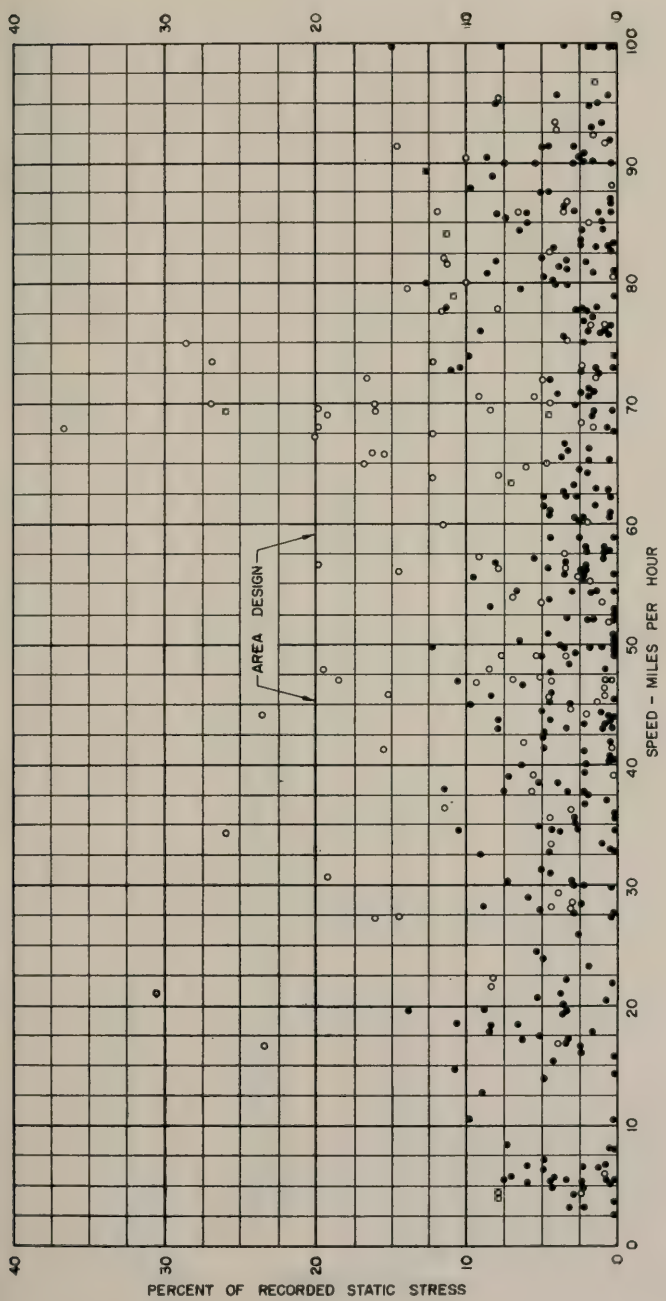
SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

FIG. 1
THROUGH AND DECK PLATE GIRDERS
40 TO 60 FT. SPANS
ROLL EFFECT AT RAIL CENTERS
DIESEL



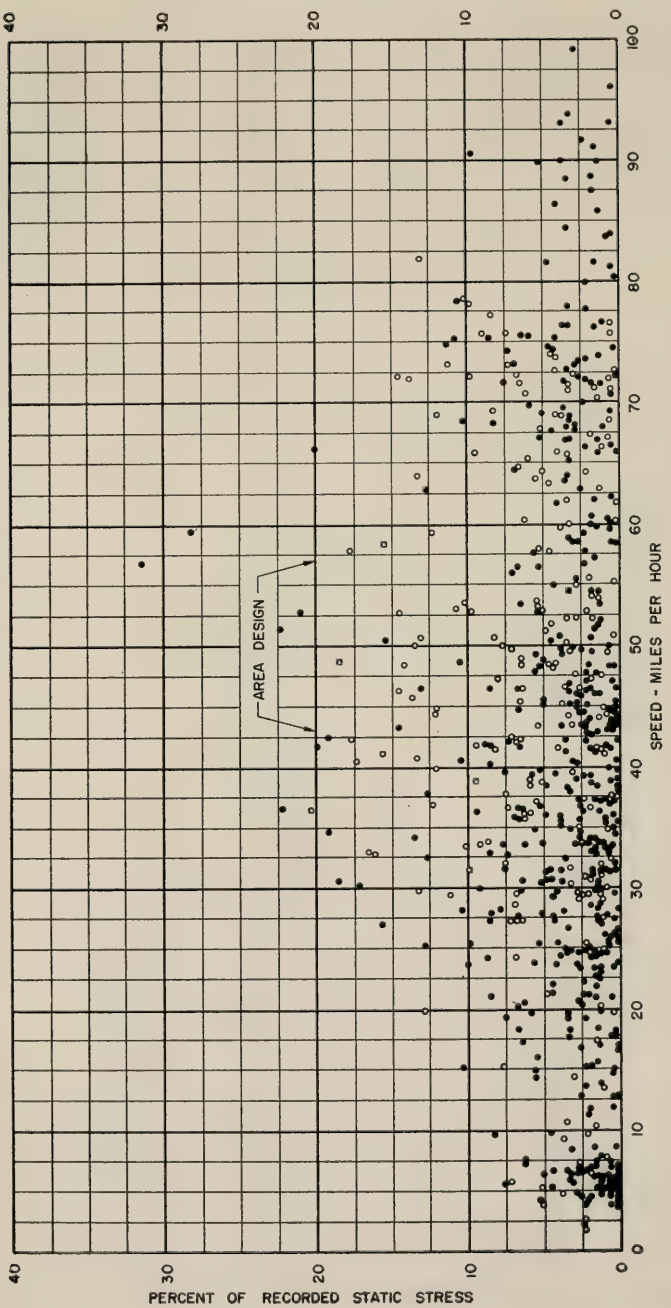
SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

FIG. 2
THROUGH AND DECK PLATE GIRDERS
40 TO 60 FT SPANS
ROLL EFFECT AT RAIL CENTERS
STEAM



SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

FIG. 3
THROUGH AND DECK PLATE GIRDERS
60 TO 90 FT SPANS
ROLL EFFECT AT RAIL CENTERS
DIESEL



SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

FIG. 4
THROUGH AND DECK PLATE GIRDERS
60 TO 90 FT. SPANS
ROLL EFFECT AT RAIL CENTERS
STEAM

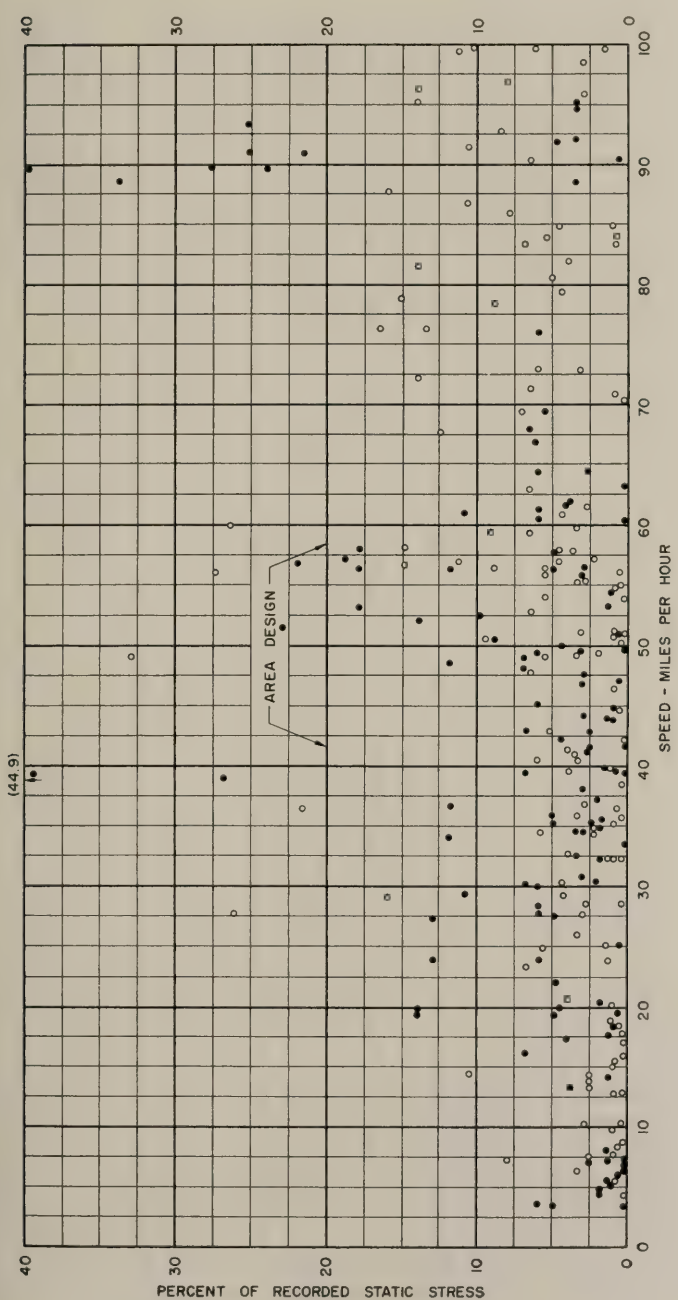
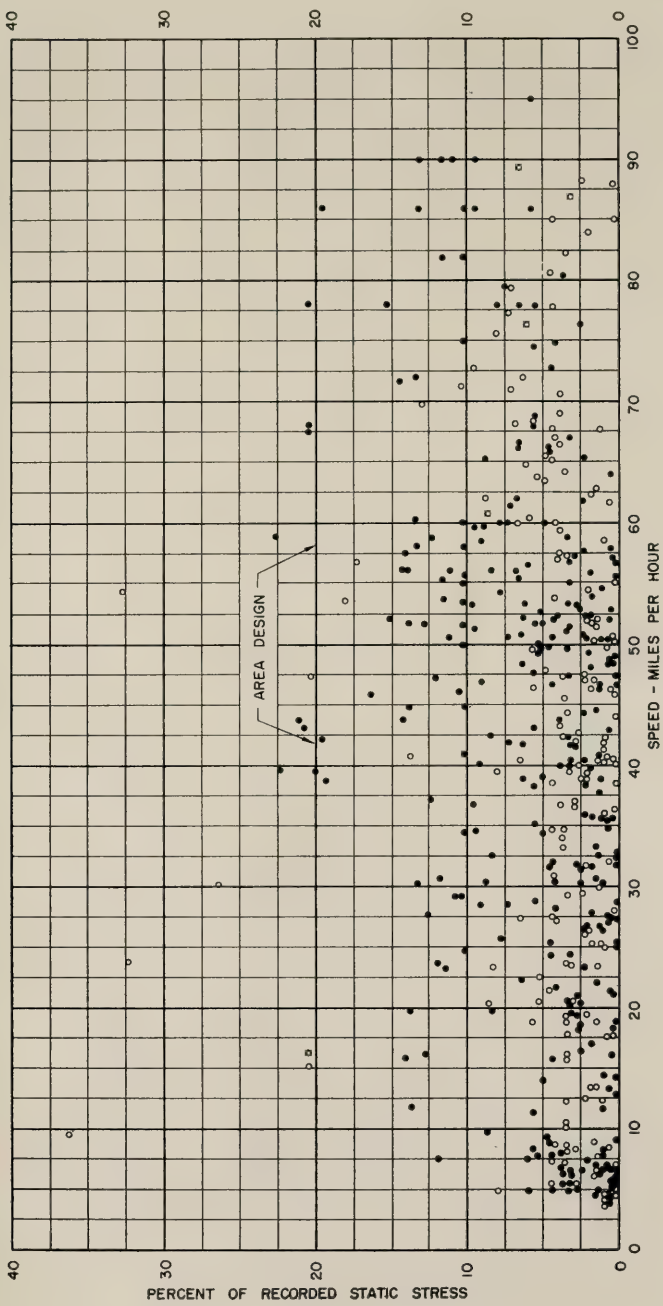


FIG. 5
THROUGH AND DECK PLATE GIRDERS
90 TO 140 FT. SPANS
ROLL EFFECT AT RAIL CENTERS
DIESEL

SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

A



SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

FIG. 6
THROUGH AND DECK PLATE GIRDERS
90 TO 140 FT. SPANS
ROLL EFFECT AT RAIL CENTERS
STEAM

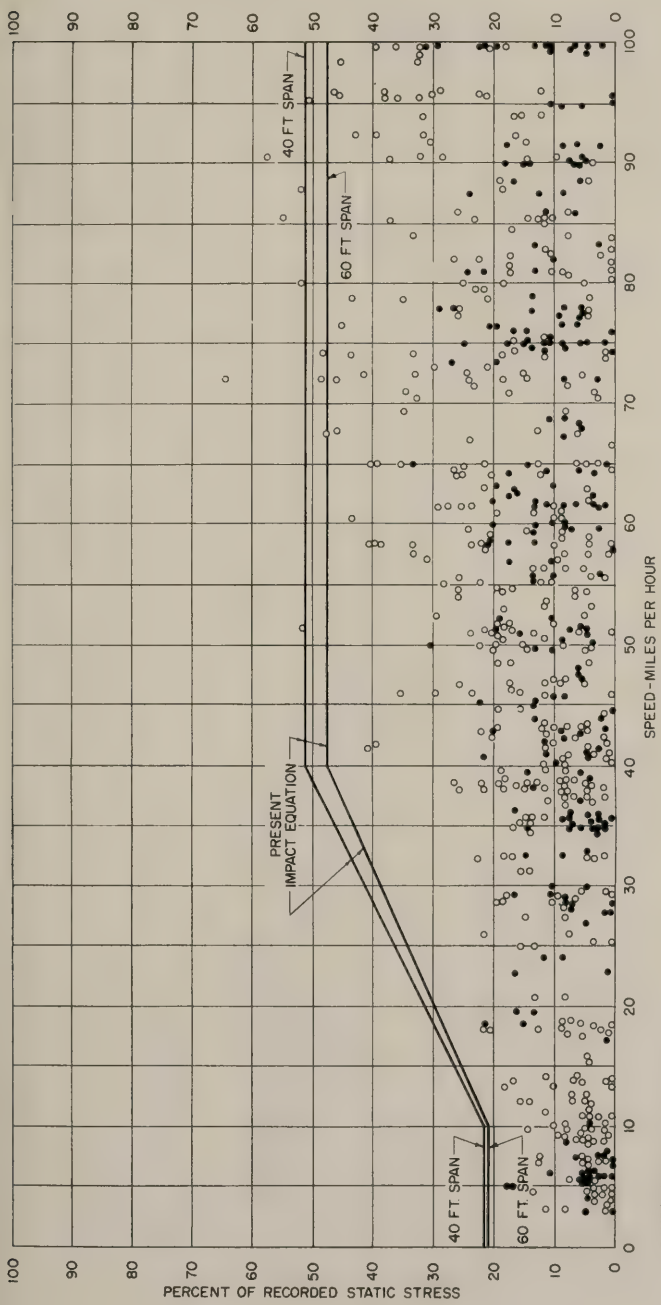
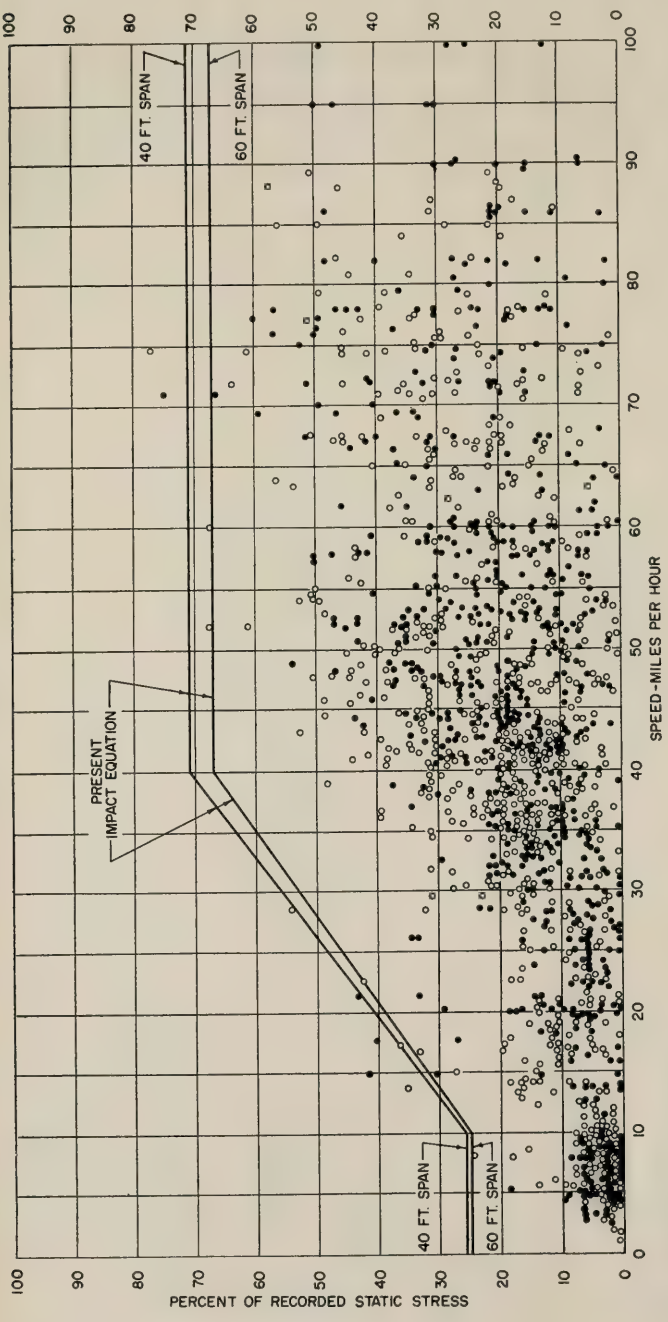


FIG. 7

THROUGH AND DECK PLATE GIRDERS
40 TO 60 FT SPANS

TOTAL IMPACTS

DIESEL



SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES
IMPACT EQUATION PER SPECIFICATIONS FOR STEEL RAILWAY BRIDGES 1958
ROLL EFFECT AT ALL SPEEDS (SEE PAGE 15-1-7)

VERTICAL EFFECT AT 40 MPH AND OVER (SEE PAGE 15-1-7) $= 60 - \frac{L^2}{500}$

VERTICAL EFFECT AT 10 MPH AND UNDER (SEE PAGE 15-7-5) $= 0.2\left(60 - \frac{L^2}{500}\right)$

NOTE: IMPACT EQUATION IS FOR SPAN LENGTHS AS SHOWN WITH GIRDERS AT 7.0 FT. CENTERS

FIG. 8

THROUGH AND DECK PLATE GIRDERS
40 TO 60 FT SPANS

TOTAL IMPACTS

STEAM

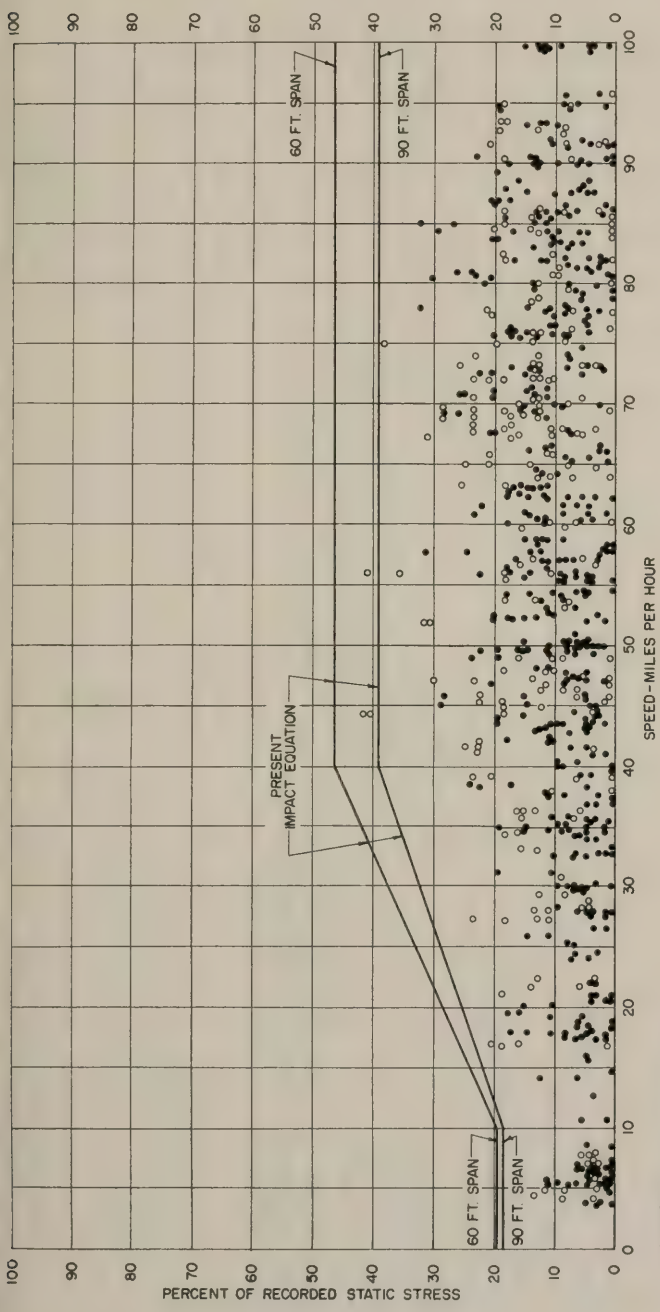
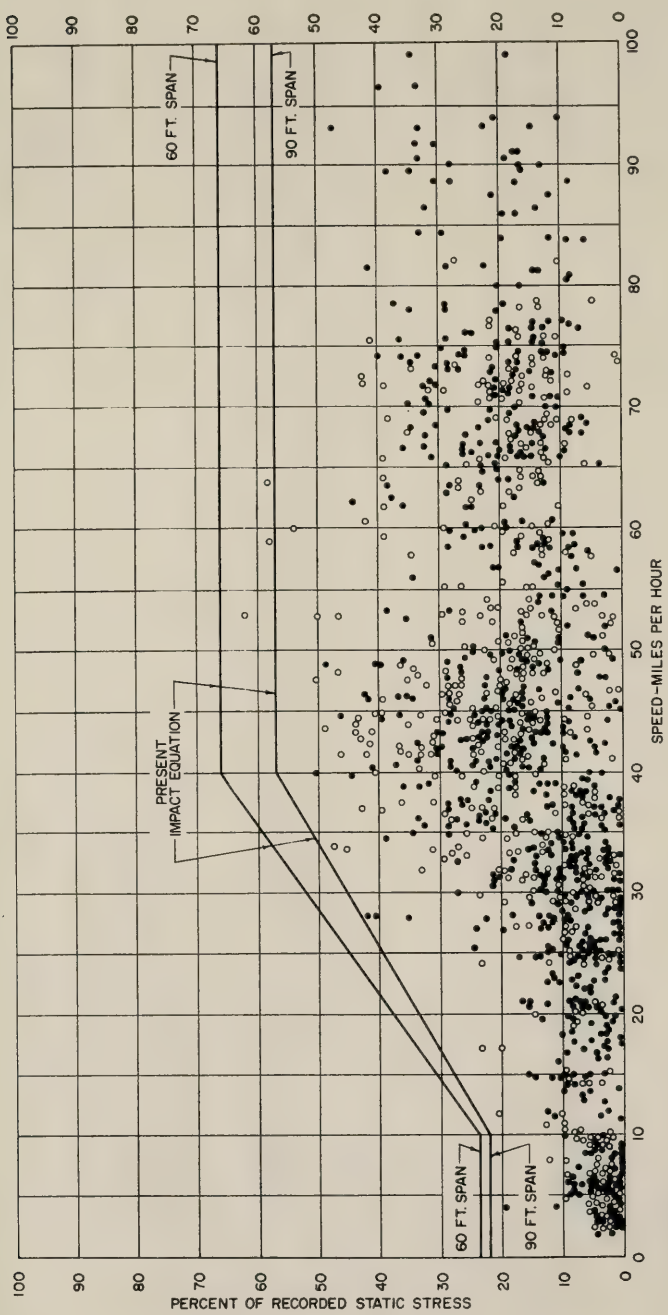


FIG. 9
THROUGH AND DECK PLATE GIRDERS
60 TO 90 FT. SPANS
TOTAL IMPACTS
DIESEL



SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

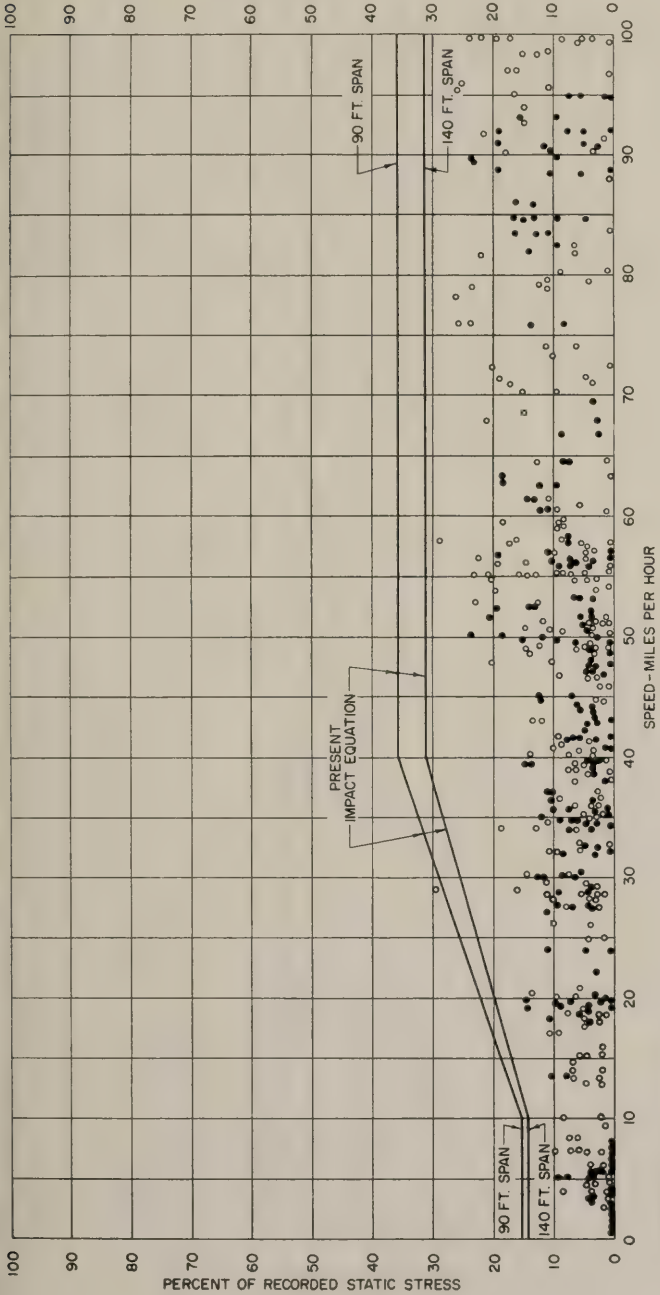
IMPACT EQUATION PER SPECIFICATIONS FOR STEEL RAILWAY BRIDGES 1958
ROLL EFFECT AT ALL SPEEDS (SEE PAGE 15-1-7)

VERTICAL EFFECT AT 40 MPH AND OVER (SEE PAGE 15-1-7) $= 60 - \frac{L^2}{500}$

VERTICAL EFFECT AT 10 MPH AND UNDER (SEE PAGE 15-7-5) $= 0.2\left(60 - \frac{L^2}{500}\right)$

NOTE: IMPACT EQUATION IS FOR SPAN LENGTHS AS SHOWN WITH GIRDERS AT 7.5 FT. CENTERS

FIG. 10
THROUGH AND DECK PLATE GIRDERS
60 TO 90 FT. SPANS
TOTAL IMPACTS
STEAM



SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

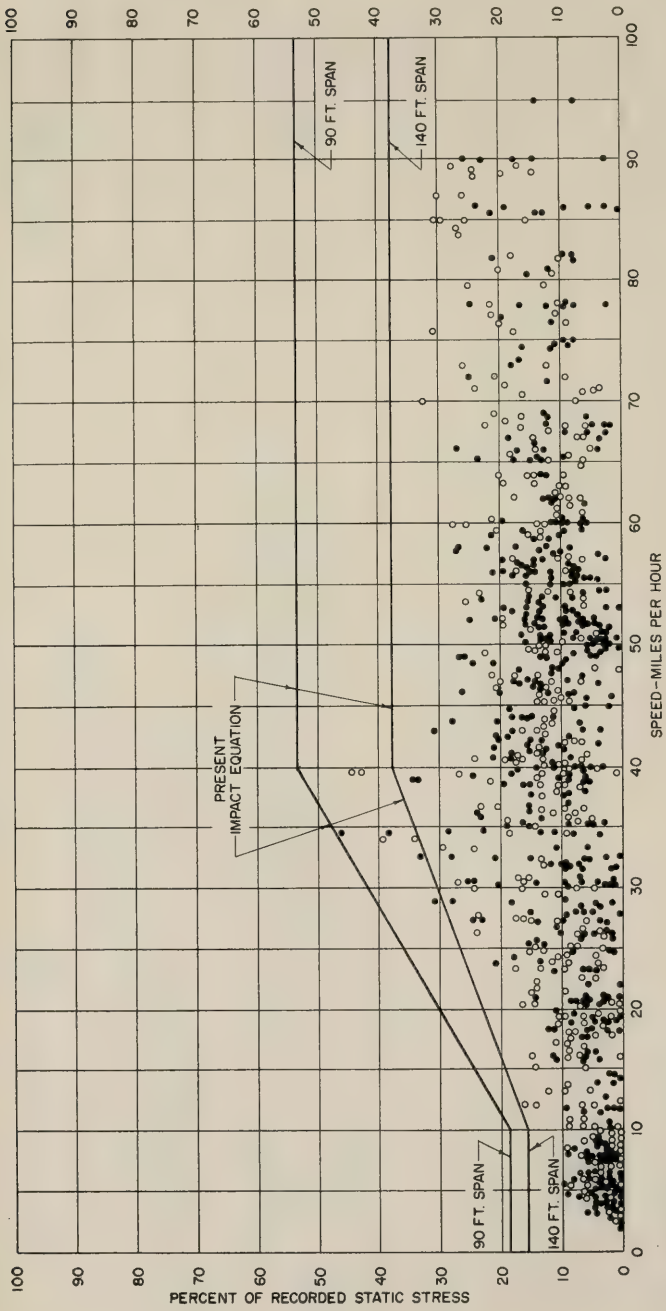
IMPACT EQUATION PER SPECIFICATIONS FOR STEEL RAILWAY BRIDGES 1958
ROLL EFFECT AT ALL SPEEDS (SEE PAGE 15-1-7)

VERTICAL EFFECT AT 40 MPH AND OVER (SEE PAGE 15-1-7) $= \frac{600}{L-30} + 16$

VERTICAL EFFECT AT 10 MPH AND UNDER (SEE PAGE 15-7-5) $= 0.2\left(\frac{600}{L-30} + 16\right)$

NOTE: IMPACT EQUATION IS FOR SPAN LENGTHS AS SHOWN WITH GIRDERS AT 10 FT CENTERS

FIG. 11
THROUGH AND DECK PLATE GIRDERS
90 TO 140 FT. SPANS
TOTAL IMPACTS
DIESELS



SYMBOLS:
○ OPEN FLOOR BRIDGES
● BALLASTED FLOOR BRIDGES

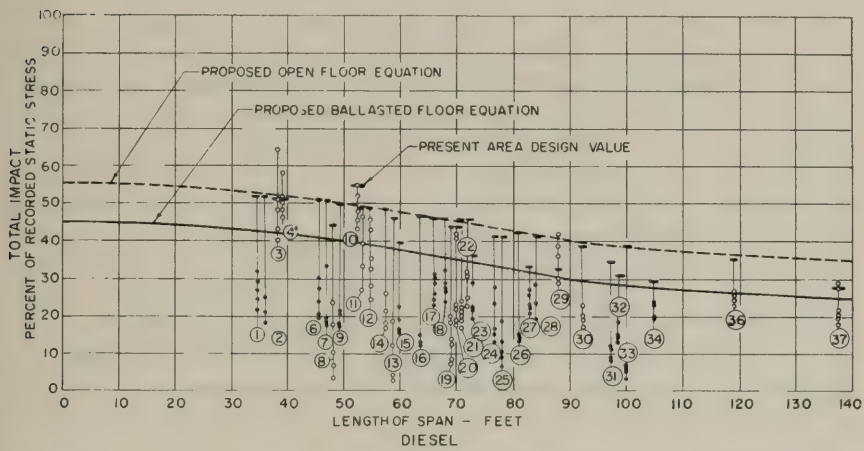
IMPACT EQUATION PER SPECIFICATIONS FOR STEEL RAILWAY BRIDGES 1958
ROLL EFFECT AT ALL SPEEDS (SEE PAGE 15-1-7)

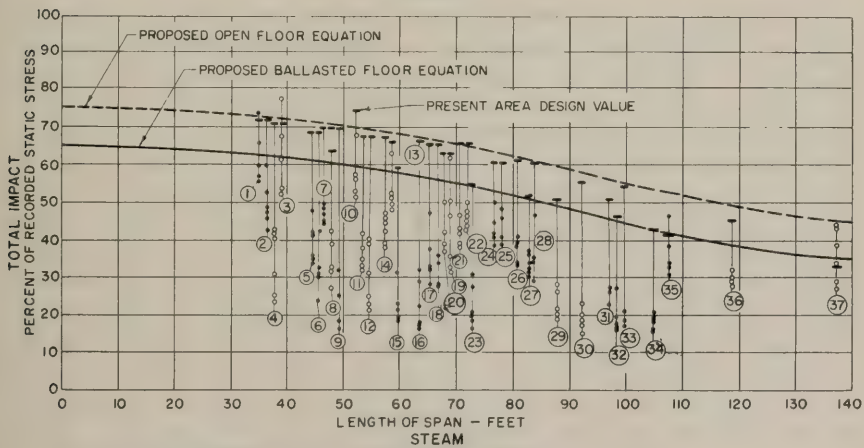
VERTICAL EFFECT AT 40 MPH AND OVER (SEE PAGE 15-1-7) $= \frac{1800}{L-40} + 10$

VERTICAL EFFECT AT 10 MPH AND UNDER (SEE PAGE 15-7-5) $= 0.2\left(\frac{1800}{L-40} + 10\right)$

NOTE: IMPACT EQUATION IS FOR SPAN LENGTHS AS SHOWN WITH GIRDERS AT 10 FT. CENTERS

FIG. 12
THROUGH AND DECK PLATE GIRDERS
90 TO 140 FT. SPANS
TOTAL IMPACTS
STEAM



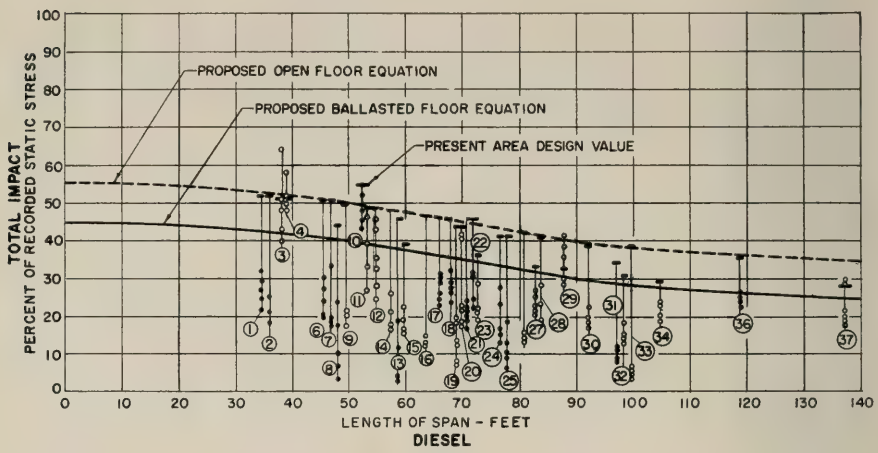


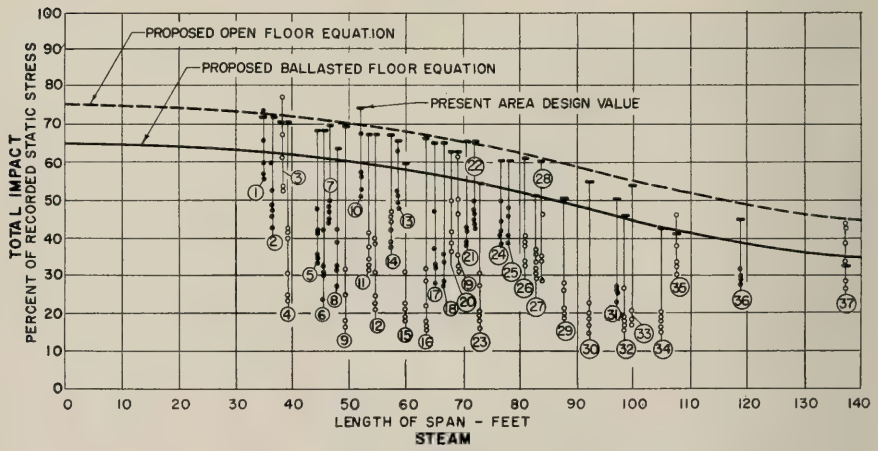
NOTE. ONLY THE SIX HIGHEST VALUES FOR EACH SPAN ARE PLOTTED
THE PROPOSED IMPACT EQUATIONS FOR DESIGN PURPOSES ARE BASED ON THE FOLLOWING

DIESEL			STEAM		
LENGTH	OPEN DECK	BALLASTED	LENGTH	OPEN DECK	BALLASTED
<80	$55 - \frac{L^2}{500}$	$45 - \frac{L^2}{500}$	<100	$75 - \frac{L^2}{500}$	$65 - \frac{L^2}{500}$
>80	$\frac{500}{L-40} + 30$	$\frac{500}{L-40} + 20$	>100	$\frac{1500}{L-40} + 30$	$\frac{1500}{L-40} + 20$

SYMBOLS: ○ OPEN FLOOR ● BALLASTED FLOOR

FIG. 13 COMPARISON OF TOTAL IMPACTS IN GIRDER SPANS SHOWING EFFECT OF TYPE OF FLOOR AND PROPOSED IMPACT EQUATIONS





NOTE: ONLY THE SIX HIGHEST VALUES FOR EACH SPAN ARE PLOTTED. SEE FIG 13 FOR PROPOSED EQUATIONS.

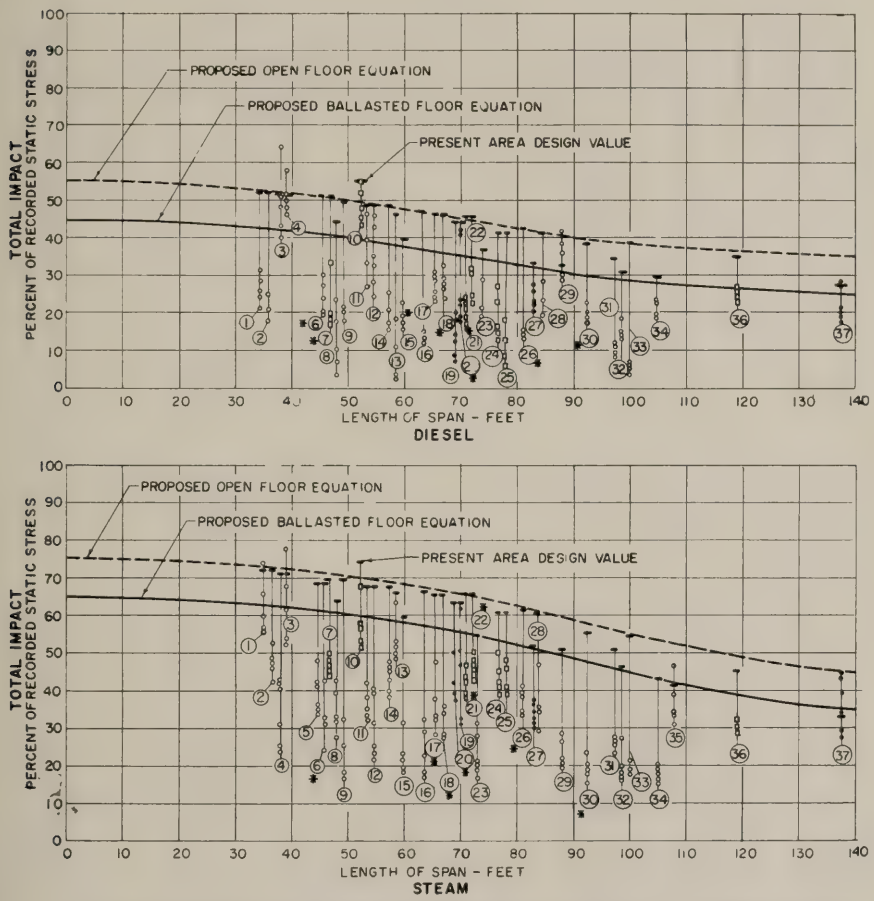
SYMBOLS:

o CAPACITY — > E80

● CAPACITY — < E80

FIG. 14

COMPARISON OF IMPACTS IN GIRDER SPANS SHOWING EFFECT OF SPAN CAPACITY



NOTE: ONLY THE SIX HIGHEST VALUES FOR EACH SPAN ARE PLOTTED SEE FIG 13 FOR PROPOSED EQUATIONS

SYMBOLS:

- ○ CONCRETE PIERS
- ● STEEL TOWERS
- ✱ ONE END ON ABUTMENT
- □ STONE PIERS

FIG 15

COMPARISON OF IMPACTS IN GIRDER SPANS SHOWING EFFECT OF TYPE OF SUBSTRUCTURE

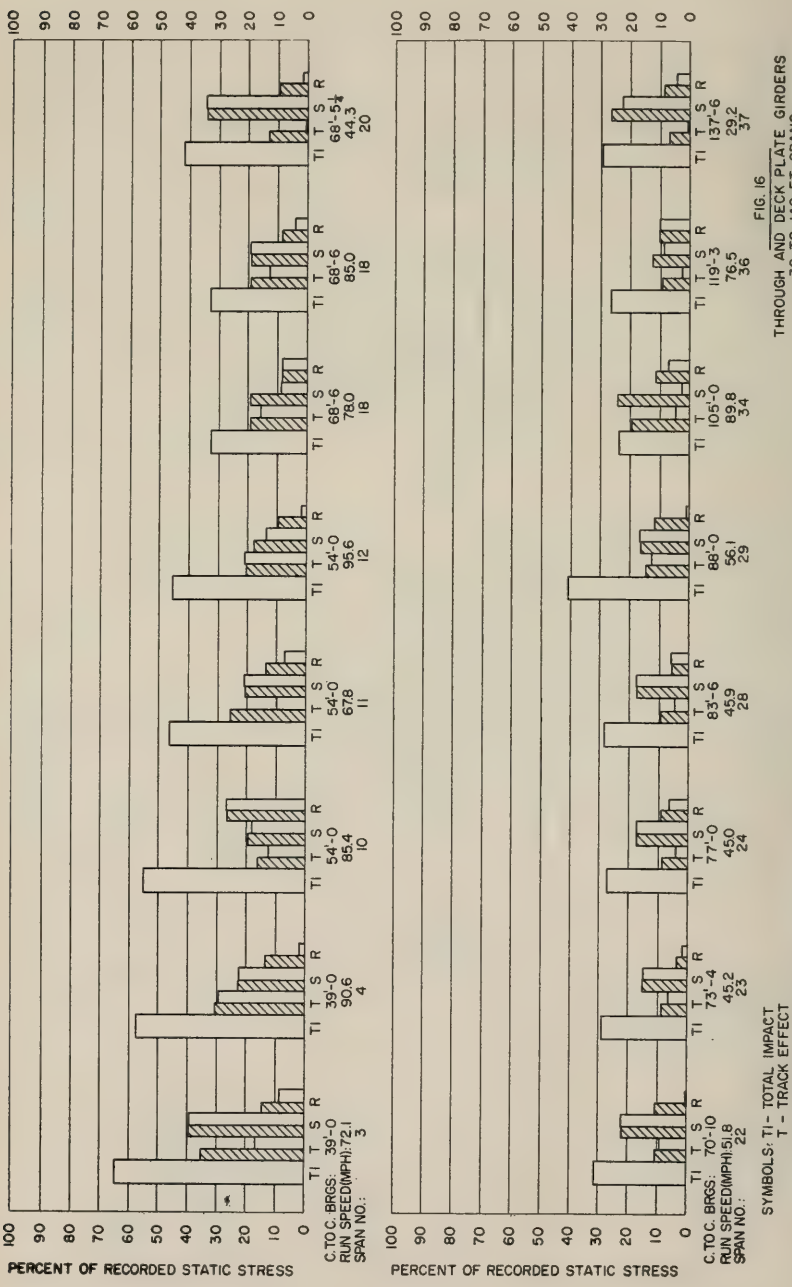


FIG. 16
THROUGH AND DECK PLATE GIRDERS
30 TO 140 FT. SPANS
RUNS PRODUCING
MAXIMUM TOTAL IMPACT
DIESEL

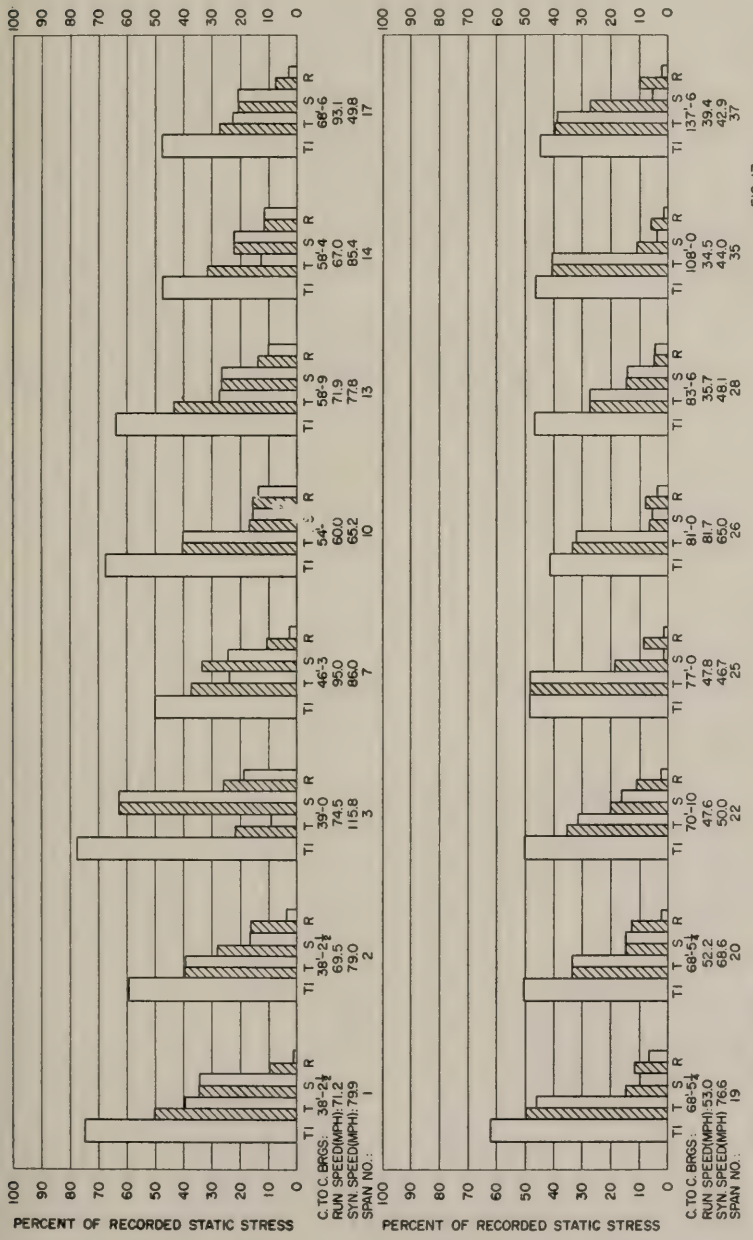
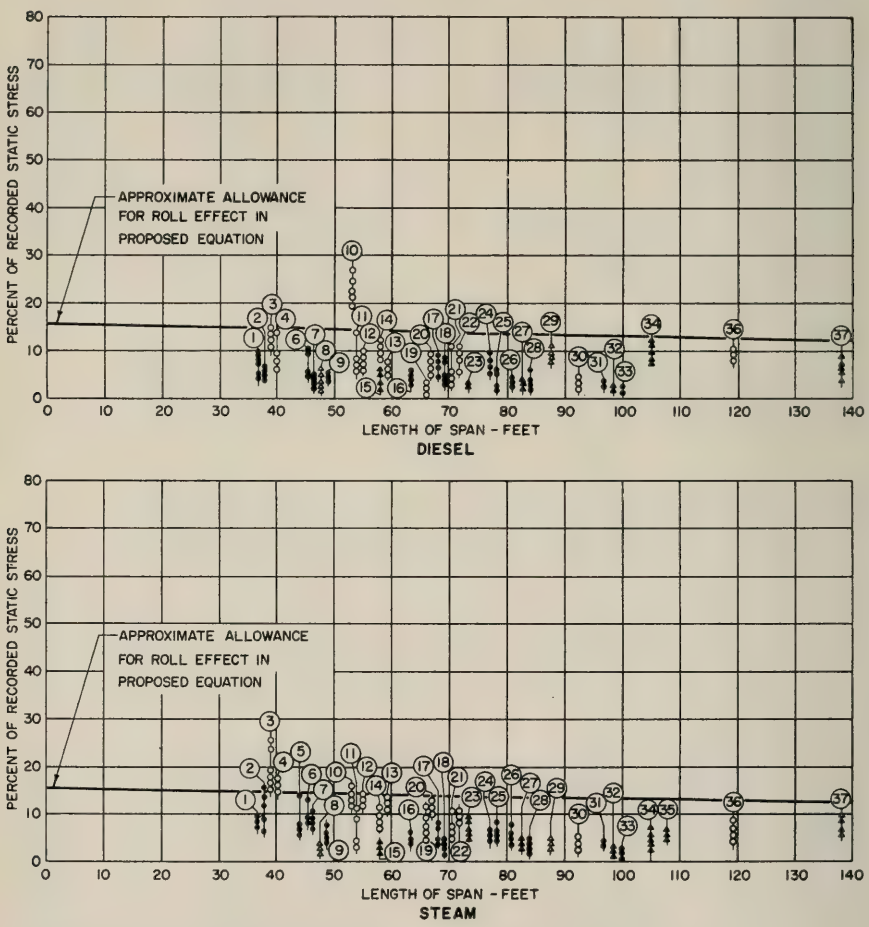


FIG. 17
THROUGH AND DECK PLATE GIRDERS
30 TO 140 FT. SPANS
RUNS PRODUCING
MAXIMUM TOTAL IMPACT
STEAM



NOTE:
ONLY THE SIX HIGHEST RECORDED VALUES FOR EACH SPAN ARE PLOTTED

SYMBOLS:
- ○ OPEN FLOOR, DECK GIRDER
- ▲ OPEN FLOOR, THROUGH GIRDER
- ● BALLASTED FLOOR, DECK GIRDER
- ▲ BALLASTED FLOOR, THROUGH GIRDER

FIG. 18

COMPARISON OF ROLL EFFECT AT GIRDER CENTERS SHOWING EFFECT OF TYPE OF GIRDER

Advance Report of Committee 7—Wood Bridges and Trestles

F. E. Schneider, *Chairman*

Static and Repeated-Load Strength of Bolted Timber Joints

A. DIGEST

This report contains a description and the results of an investigation conducted at the AAR Research Center to determine the relative static and repeated-load strength of bolted timber joints as ordinarily used to fasten the sway bracing to the piles or caps in timber pile trestle construction. Some data are available on the static strength of such a joint, but little is known of its strength when subjected to repeated loads.

Full-size timbers were included in the investigation. The variables were as follows:

Douglas fir and southern pine
3- by 8-in and 4- by 8-in sway braces
Treated and untreated timber
¾, ⅞, 1 and 1¼ in diameter bolts
Single-curve spike grid with ¾-in bolts

Comparison between the various types of joints was made on the basis of 500,000 cycles of a repeated load or a total joint slip of ¼ in (⅛ in. in each direction) whichever occurred first. Static tests of each type of joint were also conducted.

Load-cycle curves plotted for each variable are included and indicate that the repeated-load strength of a joint decreases as the number of load cycles increases. There is also an indication of increased repeated-load strength with an increase in bolt size. Higher repeated-load strengths were obtained with 4-in sway braces than with 3-in sway braces with the same size of bolts. It was also found that a full-seated spike grid used with a ¾-in bolt had a greater repeated-load strength than a similar joint with only a 1-in bolt. Regardless of the bolt size, sway-brace size, species or treatment, the average repeated-load strength at 500,000 cycles was 48 percent of the static strength.

Since this investigation represents a limited amount of data, no conclusions should be drawn as to the relative strength of treated and untreated wood or the relative strength of the two species involved.

B. FOREWORD

One of the assignments of Committee 7—Wood Bridges and Trestles, is Specifications for Design, and toward the fulfillment of this assignment the AAR research staff conducted this investigation on bolted timber joints.

The tests were performed at the AAR Research Center under the general direction of G. M. Magee, director of engineering research. The conduct of the tests, analysis of data and preparation of the report were under the direction of E. J. Ruble, research engineer structures. W. J. Murphy, former assistant research engineer structures, D. W. Wilki, chief draftsman, and I. A. Eaton, draftsman, assisted in the performance of the tests. This report was written jointly by Mr. Wilki and F. P. Drew, assistant research engineer structures.

Photograph 1—General view of timber joint repeated-load machine.

C. TEST MACHINE

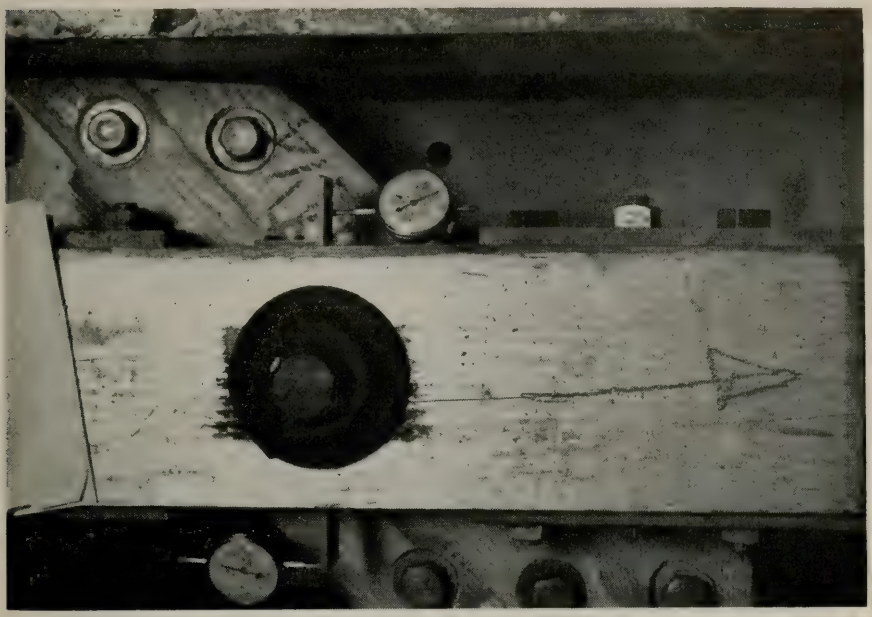
The machine used to apply repeated loads as well as static loads to the specimens is shown in Photograph 1 and diagrammatically in Fig. 1. A motor-driven gear box rotated a cam which in turn transmitted a reciprocating motion to the test specimen. Load to the specimen was controlled by regulating the amount of spring compression in the head and tail assemblies. Load was applied to the sway brace equally in each direction, while the pile specimen was rigidly bolted to the frame of the machine with its longitudinal axis 45 deg to the axis of the machine and to the sway brace. The machine operated at a rate of 1 cps.

Weigh bars in the head and tail assemblies were calibrated in a Baldwin–Southwark test machine to obtain load-strain curves. SR–4 strain gages were attached to the weigh bars, and a static strain indicator was used to determine the required load.

To measure the amount of movement between the sway brace and the pile, two Ames dials reading to 0.001 in were mounted on steel brackets on each side of the sway-brace specimen opposite the bolt, as shown in Photograph 2.

D. TEST SPECIMENS

Full-size timbers were used in this test to simulate as closely as possible actual field conditions. Both treated and untreated Douglas fir and southern pine specimens were used. Testing was performed on the untreated material first.



Photograph 2—General view of assembled bolted timber joint.

All of the untreated Douglas fir was supplied locally through the assistance of the West Coast Lumbermen's Association. Since the untreated southern pine could not be obtained locally, the Southern Pine Association arranged for shipment from Alabama.

Both the pine and fir were carefully selected to be fairly clear with a minimum of knots, a moderately straight grain and all pieces of nearly the same density. The 10 by 10's for the simulated pile tests and the 3 by 8's and 4 by 8's for the sway braces were shipped in 12 ft lengths.

Upon arrival at the laboratory the ends of the pieces were coated with paraffin and stored in the laboratory basement for several weeks prior to testing so that the moisture content would become fairly uniform.

The treated Douglas fir was purchased locally. Actual pile sections were obtained in 10-ft and 25-ft lengths and these were selected to have a minimum diameter of 14 in. The 3- by 8-in and 4- by 8-in sway-brace material was obtained in 16-ft lengths and carefully selected to have similar physical characteristics to the untreated lumber. The treatment consisted of a 10-lb retention of grade No. 1 creosote.

The first few tests with treated southern pine were made on pile cutoffs furnished by the Burlington Railroad. These had been treated with 14 lb of grade No. 1 creosote. The supply of the cutoffs was not adequate, and it was necessary to purchase additional pile sections. These had been treated with a 10-lb retention of creosote. In each case the pile section was chosen to have a minimum diameter of 14 in. The Burlington Railroad also furnished 4- by 8-in sway-brace material from their material stock. It was treated with 10 lb of creosote. The 3- by 8-in sway-brace material was purchased in 12- and 16-ft lengths treated with 10 lb of creosote.

About the time the treated material was being accumulated, a high-humidity timber storage room was built at the Research Center. All timber was then kept in this room until ready to assemble in the test machine.

The bolts used to connect the sway brace to the pile were purchased in sizes, ¾ in, ⅞ in, 1 in and 1¼ in.

Part of the investigation was performed with a mechanical fastener between the sway brace and the pile surface. Only one type of fastener was used. This was a single-curve spike grid furnished by the Timber Engineering Company. This grid is shown in the center of Photograph 3.

As many test specimens were cut out of a piece as possible. This was important in order to have at least one specimen for the static test and several others for the repeated-load tests. Matched specimens were thus tested, providing a more definite relationship of static and repeated-load strength.

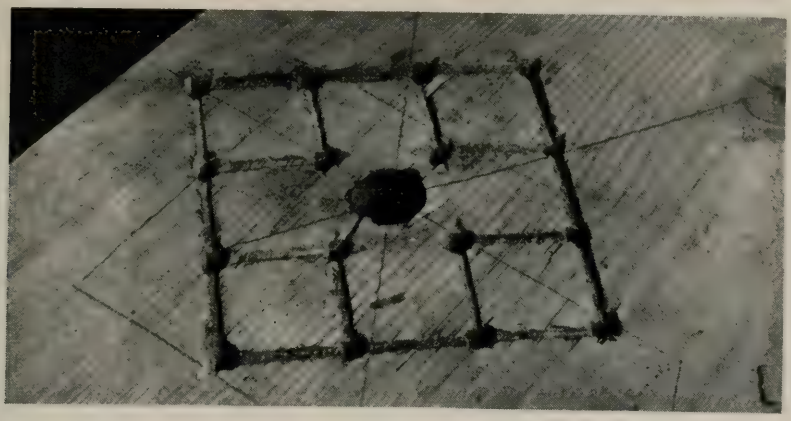
The number of specimens obtained from a single piece varied since it was important that the bolt hole be located in an area free of knots, splits or other local effects. Each test specimen was marked to provide identification with respect to treatment, species, size and location in the original piece as follows:

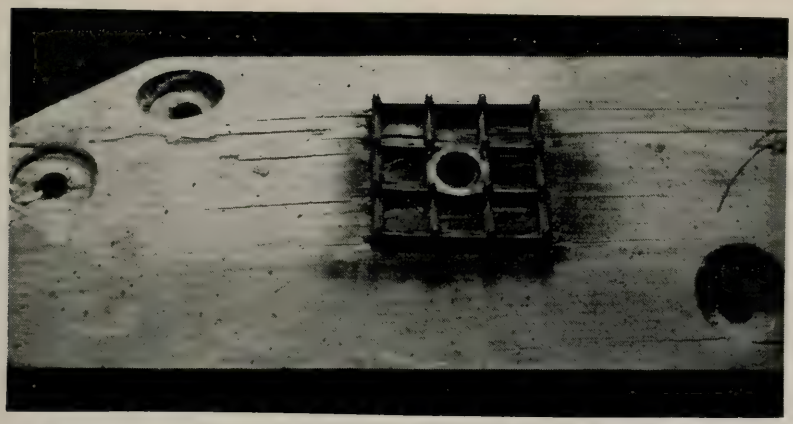
First symbol: T for treated, blank for untreated.
Second symbol: F for fir, P for pine.
Third symbol: 3 for 3-in sway brace, 4 for 4-in sway brace.
Fourth symbol: A, B, C, D, E, etc., location of the specimen in the original piece.
Fifth symbol: 1, 2, 3, etc., number of the original piece from which the specimens were cut.

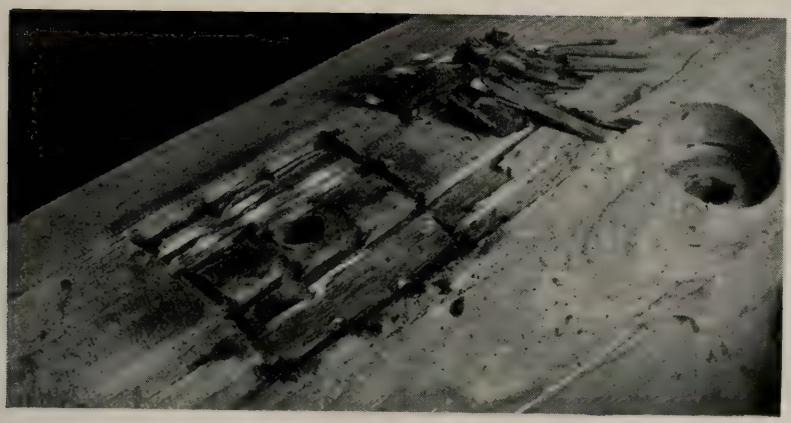
Thus a specimen marked TF–3E2 indicates treated fir, 3-in sway brace, fifth piece from the end of the original piece number 2. Sway brace and pile specimens were marked similarly, except that for the piles the third symbol was omitted. Specimen marks as they appear in the tables of this report have been abbreviated for simplicity by elimination of the first two symbols, since the title of each table covers this.

After marking, the sway brace and pile specimens were cut and drilled as shown on Fig. 1. The ends of the untreated specimens were coated with paraffin. Special care was taken in drilling the hole for the sway-brace-to-pile connection bolt. New bits were used as far as practical and were discarded when they became dull. The holes were drilled the same size as the bolt. During assembly of the specimens in the test machine the hole in the center of the sway brace and pile was lined up and the bolt driven lightly into position with a mallet. Care was taken not to drive the bolt too hard to avoid damage to the wood fibers. OG washers were used under the head and nut. In those joints tested without a mechanical fastener the nut was kept only fingertight, but in the case of joints with the mechanical fastener the nut was kept wrench tight to keep the fastener seated.

Assembling the joint with the mechanical fastener entailed certain procedures established by the manufacturer. To fully seat this type of fastener considerable force is necessary, and in most cases a high-strength rod and ballbearing washer were used to accomplish this. However, in order to fully seat the connection in the treated Douglas fir it was necessary to press the timbers together under a load of as much as 25,000 lb. This was done in the Baldwin–Southwark testing machine (see notes on Fig. 14.) The fastener was considered fully seated when the surfaces of the sway brace and the pile were 3/16 in apart. Certain tests were also run with the fastener only half seated, and in this case the two surfaces were ⅝ in apart.







Photograph 3—General views of bolted grid joint upon completion of test.

The total number of tests, distributed among the various variables, is shown in Table 1.

The moisture content of the sway-brace specimen and the pile specimen was measured with a Delmhorst moisture meter using 5/16-in tips. Readings were taken close to the bolt hole immediately before and after each test. The recorded percentage values are the average of these two readings and appear on Tables 2 to 9 incl. Additional details of this moisture meter and a discussion of strength-moisture relationships have been published in the AREA Proceedings, Vol. 60, page 143 under "Tests of Timber Trestles on the Seaboard Air Line Railroad."

At the conclusion of each test an increment boring was taken from the sway brace and the pile specimen. These were used to determine the specific gravity of the wood. The recorded values are shown on Tables 2 to 9, incl. A detailed description of how the specific gravity was determined from such borings as well as a discussion of the strength-specific gravity relationship is included in the Proceedings just referred to.

E. STATIC TESTS

Since the static tests are the basis to which the strength of the joints in repeated load is releated, a representative number of static tests were performed in proportion to the number of repeated-load tests. At least one static test was run for each repeated-load test, and additional static tests were run depending upon the availability of test specimens.

The static test was performed in the repeated-load machine by hand-cranking the machine to produce load in one direction only. The load was applied in 200-lb increments and simultaneous readings taken on the two Ames dials and on the weigh-bar strain gages. Thus the joint slip in inches and the axial load in pounds applied to the sway braces were obtained. The static test was discontinued when the slip in one direction reached 0.3 in or a load of 10,000 lb, which was the capacity of the machine. The results of these static tests are shown in the left diagrams of Figs. 2 to 32, incl., and from these curves the load required to produce ⅛ in slip in each direction was obtained. Such values appear in Tables 2 to 9 incl.

F. REPEATED-LOAD TESTS

Upon completion of the static tests on each type of specimen, repeated-load tests were made on similar specimens for each type of joint. The static-load values at the ⅛ in slip formed the basis for determining the value of repeated load to use. Generally, repeated-load values ranging between 40 percent and 80 percent of the average static load were selected. There were no predetermined number of tests to run; the number varied with each type of joint in order that enough points be obtained to plot an S–N, or load-cycle, curve.

In order to compare the various types of joints under repeated loading a total slip of ¼ in or ⅛ in. in each direction between the sway brace and the pile was arbitrarily selected as the failure point for all joints. If this slip was not attained after 500,000 cycles, the test was discontinued. Since the repeated load tests were conducted with the load applied equally in opposite direction and the static tests were made with the load applied only in one direction, ⅛-in slip in the static test corresponds to ¼-in slip in the repeated load tests.

Readings were taken during the repeated-load tests similar to the static tests. The amount of joint slip was recorded hourly or oftener, depending on the rate of change of the readings. These tests were, of course, run at a constant load and this load was checked daily and corrections made as necessary. The data thus obtained at the various load levels are shown in the graph at the upper right of Figs. 2 to 32, incl., for each type of joint. From these data the number of cycles at the various load levels to produce ¼ in slip was determined, and is shown in the tabulation on the lower part of Tables 2 to 9 incl. In several instances it will be noted that an asterisk appears opposite the number of cycles. This indicates the value was projected from the existing data. For example, on Table 2 the repeated load test with the 1¼-in bolt at 3900 lb (specimen 3E4) indicates the ¼-in slip occurred after 275,000 cycles had been applied. Referring to Fig. 5 it is noted that this particular test was discontinued before the ¼-in slip had been reached due to a machine failure. Extropolation of the curve indicates that the specimen probably would have gone 275,000 cycles before ¼-in slip occurred. Also, on Table 2 the symbol ">500,000" indicates the specimen went 500,000 cycles without failure.

G. DISCUSSION OF TEST DATA

Since the object of these tests was to determine the relative strength of the various joints under static and repeated loading, S–N or load-cycle curves were plotted. Such curves are shown on Figs. 33 to 36 incl. They were plotted from the test data previously described in Table 10 and show the number of repeated loads the various joints withstood before a total slip of ¼ in occurred. (One-half cycle corresponds to a static load.) None of the repeated-load tests were completed at exactly 500,000 cycles, but it is possible from the existing data shown on the right diagram of Figs. 2 to 32 incl., to estimate the load which would cause ¼ in slip at 500,000 cycles. For example, on Fig. 9 the repeated-load tests made indicate that when the load was 2400 lb the total slip was only 0.2 in at 500,000 cycles, but for 3900 lb ¼ in slip occurred in only 100,000 cycles. Therefore, a curve indicated by the dotted line was drawn to intersect at the ¼-in slip and the 500,000 cycle coordinates. Interpolating between 2400 lb and 3900 lb, the load value for this curve is seen to be about 2800 lb. This same procedure was followed for all repeated-load graphs shown on Figs. 2 to 32 incl., and the load value indicated in Col. 7 of Table 10. Also shown on Table 10, Col. 4, are the static, or one-half cycle, values taken from the average curves, Fig. 2 to 32 incl.

It can be seen on Fig. 33, for instance, that a 1-in bolt in a 4- by 8-in untreated Douglas fir sway brace carried about 6400 lb as a static load, but only 3900 lb when repeated for 102,000 cycles and only 2800 lb repeated for 500,000 cycles. Thus for each size of sway brace, each species and whether treated or untreated, the family of curves shown indicates that the repeated-load strength decreases as the number of load cycles increases. Also apparent is an increase in repeated-load strength with an increase in bolt size. There is also good indication that higher repeated-load strengths were obtained with the 4-in sway braces than with the 3-in sway, using the same size of bolts.

It is interesting to note the increase in repeated-load strength obtained by the use of a mechanical fastener when fully seated. The repeated load strength at 500,000 cycles of a fully seated spike grid joint with a ¾-in bolt appears to be about 3 times the strength without the grid. While only one series of tests was run using a half-seated grid, Fig. 36 indicates that the effectiveness of this grid is measurably reduced by not being fully seated. It should also be noted that a joint comprising a ¾-in bolt and a spike grid fully seated has a greater repeated-load strength than a similar joint with

a 1-in bolt. This is particularly apparent on Figs. 33, 35 and 36, but the strength of the two types of joints is very nearly the same for the joint on Fig. 34.

Photograph 3 shows three views of a disassembled bolted timber grid joint after testing. This joint was of fir with a 3- by 8-in sway brace, ¾-in bolt and the spike grid. It had been subjected to 285,000 cycles of a 3680 lb load. Total joint slip was 0.297 in. The top photograph shows the impression of the spike grid on the 3- in by 8-in sway brace. The load was applied parallel to the grain. The center photograph shows the grid in place on the curved surface of the 10- by 10-in timber. Here the load was applied 45 deg to the grain. The lower photograph is of the same specimen with the spike grid removed. Pieces of the surface timber that had broken loose due to the action of the grid are shown piled at the upper right.

It must be admitted that these S–N curves were drawn with a very limited amount of data, and to adequately establish definite load-cycle relationships many more tests need to be run. These tests, therefore, must be considered somewhat exploratory. Some of the results presented herein might erroneously be interpreted to indicate that treated wood is stronger than untreated wood, but such a conclusion must not be drawn from these. The test results should also not be construed to indicate comparable strengths between species since variations in moisture content, specific gravity and other uncontrolled factors make such a comparison very misleading.

Insofar as possible matched specimens were used for corresponding static and repeated load tests, but it was not possible to match all the tests involving all the variables. An attempt was made to secure uniformity in the specific gravity and moisture content, but such was practically impossible, and the data for such on Tables 2 to 9 incl., indicate the spread of values obtained. Even if all the specific gravity and moisture content values of Tables 2 to 9 are averaged for each bolt size, sway-brace size, species and treatment, it can be seen from Table 10 that there still is considerable spread of values.

It seems, therefore, that adjusting the strength values obtained to a common specific gravity and moisture content is not warranted in the light of the number of variables involved and the limited number of tests. A more realistic comparison of the test data can be made by indicating the repeated-load strength at 500,000 cycles as a percentage of the average static strength. This has been done, and the percentages are shown on Tables 2 to 10 incl. Also shown on Table 10 in Col. 11 is an average of the averages for the individual bolt sizes. It is interesting to note that the average of all these values is 48 percent. In other words, regardless of the bolt size, sway-brace size, species or treatment the average repeated-load strength at 500,000 cycls is 48 percent of the static strength. This is shown graphically on Fig. 37, where the percentage values of all the repeated load tests are plotted. While the average is 48 percent for 500,000 cycles, some values were as high as 67 percent and some as low as 27 percent for a spread of about 20 percent plus and minus. (The average percentage at one-half cycle or static strength should be 100 percent.) The plot of values has been enveloped by two curves as shown to produce a spread band the width of which remains fairly constant from a very few cycles of loading to 500,000 cycles, indicating that similar variables were present in all the tests. The plot of values has been separated between the two species, but it can be seen that no comparison is warranted.

H. CONCLUSIONS

The strength and performance of bolted structural timber joints as used in railway trestle construction where they are subjected to repeated loads has never been satisfactorily known. The tests reported herein are exploratory in character, but nevertheless do permit certain general conclusions to be drawn as a guide in the evaluation of joint strengths. Due to variability in moisture content and specific gravity, and other conditions, the strength of the individual specimens is not comparative. In particular, no conclusions should be drawn between the strength of wood species or between untreated and treated wood from the data presented herein.

The following data are regarded as reasonably indicative of the strength of joints using bolts of varying size under roughly comparable conditions of use, and with the load applied parallel to the grain of the sway brace and at 45 deg to the grain of the pile:

1. The static and repeated-load strength of ordinary bolted joints increases with increased size of bolt. A joint with 1-in bolts, for example, appears to have roughly double the strength of a joint with ¾-in bolts.

2. The static and repeated-load strength of bolted joints is greater for a 4- by 8-in sway brace than for a 3- by 8-in sway brace.

3. A joint connected with a mechanical fastener of the spike grid type must be fully seated into the wood to develop its maximum strength; its strength is very much less for a grid only partly seated. Provided the grid is fully seated, a ¾-in bolt with 4-in spike grid fastener appears to have a strength equal to or greater than a 1-in bolt.

4. The repeated-load strength decreases as the number of cycles of stress is increased. For example, the repeated load strength at 500,000 cycles tends to approximate one-half the static strength, irrespective of species or whether the timber is untreated or treated according to ordinary specifications.

TABLE 1
NUMBER OF TESTS
BOLTED TIMBER JOINT STUDIES
DOUGLAS FIR & SOUTHERN PINE

Species and Treatment	Size of Sway Braces	Number of Tests					
		2 O. G. Washers		Fully Seated Grid		Half Seated Grid	
		Static Load	Repeated Load	Static Load	Repeated Load	Static Load	Repeated Load
Treated Douglas Fir	3 x 8	6	7	1	3		
	4 x 8	4	9				
Untreated Douglas Fir	3 x 8	12	14	3	4		
	4 x 8	12	12				
Total Number of Tests For Douglas Fir	Subtotal	24	26	4	7	0	0
	Total	50		11		0	
Treated Southern Pine	3 x 8	13	20	5	4	4	5
	4 x 8	7	12				
Untreated Southern Pine	3 x 8	9	13				
	4 x 8	9	16				
Total Number of Tests For Southern Pine	Subtotal	38	61	5	4	4	5
	Total	99		9		9	

See Table 10 for summary of results.

TABLE 2
BOLTED TIMBER JOINT STUDIES
UNTREATED DOUGLAS FIR

3 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.		1 in.		1 1/4 in.		3/4 in.**	
		Sway	Pile	Sway	Pile	Sway	Pile	Sway	Pile	Sway	Pile
Static Tests	Specimen Number	3A1	A1	3C1	C1	3D1	D1	3E3	E3	3G1	G3
	Specific Gravity	.528	.452	.462	.520	.582	.434	.549	.449	.503	.462
	Percent of Moisture Content	28.7	34.1	13.4	17.0	12.4	13.7	9.9	10.9	15.0	16.9
	Load at 1/8 in. Slip	2500		5400		5700		5550		7300	
	Specimen Number	3A3	A3	3C3	C3	3D3	D3	3F1	F1	3G2	G5
	Specific Gravity	.528	.452	.462	.520	.582	.434	.432	.396	.503	.462
	Percent of Moisture Content	27.0	26.9	16.3	21.0	13.3	16.1	17.0	19.0	15.4	17.0
	Load at 1/8 in. Slip	3200		4200		4800		8100		6800	
	Specimen Number	3B1	B1	3B3	B3	3E1	E1	3F3	F3	3G3	H1
	Specific Gravity	.501	.508	.501	.508	.549	.449	.432	.396	.503	.472
	Percent of Moisture Content	20.4	20.6	16.5	20.8	13.8	13.3	9.3	8.9	15.3	17.2
	Load at 1/8 in. Slip	3150		4000		4900		6500		8100	
	Average Static Load	2950		4533		5133		6717		7400	
Repeated Load Tests	Specimen Number	3B2	B2	3B4	B4	3X1	B5	3F2	F2	3G4	H2
	Specific Gravity	.501	.508	.501	.508	.514	.526	.432	.396	.503	472
	Percent of Moisture Content	17.0	20.3	10.9	13.0	9.0	9.0	9.5	8.7	17.6	18.6
	Number of Cycles for 1/4 in. Slip	205,000*		242,000		350,000		> 500,000		>500,000	
	Load	1200		1400		2000		2400		1840	
	Percent of Average Static Load	40.0		31.1		38.4		36.1		24.7	
	Specimen Number	3A4	A4	3C2	C2	3E2	E2	3F4	F4	3H2	H4
	Specific Gravity	.528	.452	.462	.520	.549	.449	.432	.396	.513	.472
	Percent of Moisture Content			14.0	19.5	11.8	11.3	9.5	9.9	21.8	19.6
	Number of Cycles for 1/4 in. Slip	15,000		90,000*		>500,000		200,000*		>500,000	
	Load	1500		2100		2000		3900		2760	
	Percent of Average Static Load	50.0		46.6		38.4		58.6		37.1	
	Specimen Number	3A2	A2	3C4	A5	3D4	D4	3E4	E4	3H1	H3
	Specific Gravity	.528	.452	.462	.452	.582	.434	.549	.449	.513	.472
	Percent of Moisture Content	25.9	29.3	11.5	15.2	11.6	12.9	9.3	10.2		19.1
	Number of Cycles for 1/4 in. Slip	10,000		17,000		15,000		275,000*		238,000	
	Load	1500		3150		3250		3900		3680	
	Percent of Average Static Load	50.0		70.0		62.5		58.6		49.4	
	Specimen Number					3D2	D2	3X2	F5 +	3H3	H5
	Specific Gravity					.582	.434	.514		.513	.472
	Percent of Moisture Content					12.2	13.9			19.0	18.3
	Number of Cycles for 1/4 in. Slip					1000		101,000		30,000	
	Load					4500		4800		4600	
	Percent of Average Static Load					86.5		72.1		61.8	

*Projected Value
**With a 4 1/8 in. Single Curve Spike Grid
+With 1/2 in. Shim

TABLE 3
BOLTED TIMBER JOINT STUDIES
UNTREATED DOUGLAS FIR
4 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.		1 in.		1 1/4 in.	
		Sway	Pile	Sway	Pile	Sway	Pile	Sway	Pile
Static Tests	Specimen Number	4A1	A1	4B1	C1	4C1	D1	4D1	F1
	Specific Gravity	.502	544	.472	.493	.512	.438	.564	
	Percent of Moisture Content	11.8	17.7	13.1	13.3	14.0	10.3	9.6	13.0
	Load at 1/8 in. Slip	2800		3900		6100		8350	
	Specimen Number	4A3	A3	4B3	C3	4C3	D3	4D3	F3
	Specific Gravity	.502	.544	.472	.493	.512	.438	.564	
	Percent of Moisture Content	10.5	15.3	12.0	13.0	10.8	10.2	9.8	10.7
	Load at 1/8 in. Slip	2950		5100		6450		10,400*	
	Specimen Number	4A5	B1	4B5	B3	4C5	E1	4D5	E3
	Specific Gravity	.502	.526	.472	.526	.512	.514	.564	.414
	Percent of Moisture Content	9.7	15.1	12.0	14.4	11.5	10.8	9.6	9.5
	Load at 1/8 in. Slip	2200		4800		6550		9100	
	Average Static Load	2650		4600		6367		9283	
Repeated Load Tests	Specimen Number	4A4	A4	4B2	B4	4C2	D2	4D2	F2
	Specific Gravity	.502	.544	.472	.526	.512	.438	.564	
	Percent of Moisture Content	13.4	15.3	12.1	13.7	10.6	10.5	9.0	10.6
	Number of Cycles for 1/4 in. Slip	188,000		> 500,000		> 500,000		> 500,000	
	Load	1200		1680		2400		3000	
	Percent of Average Static Load	45.3		36.5		37.5		32.6	
	Specimen Number	4A2	A2	4D7	A5	4D4	D4	4D6	E4
	Specific Gravity	.502	.544	.564	.544	.512	.438	.564	.414
	Percent of Moisture Content	13.0	16.7	8.7		11.7	11.3		9.5
	Number of Cycles for 1/4 in. Slip	26,000		136,000		102,000		>500,000	
	Load	1950		2730		3900		3200	
	Percent of Average Static Load	73.6		59.4		60.9		34.8	
	Specimen Number	4A6	B2	4A7	C4	4C6	E2	4D4	F4
	Specific Gravity	.502	.526	.502	.493	.512	.414	.564	
	Percent of Moisture Content	10.6	14.0	12.3	12.3	12.1	11.3	8.5	9.8
	Number of Cycles for 1/4 in. Slip	2000		28,000		1000		460,000	
	Load	2700		3780		5400		4200	
	Percent of Average Static Load	102.0		82.2		84.4		45.6	

* Projected Value

TABLE 4
BOLTED TIMBER JOINT STUDIES
TREATED DOUGLAS FIR
3 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.		1 in.		3/4 in.*	
		Sway	Pile	Sway	Pile	Sway	Pile	Sway	Pile
Static Tests	Specimen Number	C4	3B2	3D4	F7	3D1	E3	3E3	F3
	Specific Gravity		.463	.446	.526	.493	.457	.542	.561
	Percent of Moisture Content	12.1	13.8	12.5	12.2	12.3	13.0	12.2	15.6
	Load at 1/8 in. Slip	4450		5800		6900		6000	
	Specimen Number	C2	3B1	3E1	E1				
	Specific Gravity		.498	.491	.458				
	Percent of Moisture Content	13.0	13.7	11.8	12.3				
	Load at 1/8 in. Slip	3600		6700					
	Specimen Number	C3	3A1						
	Specific Gravity		.525						
	Percent of Moisture Content	13.0	12.9						
	Load at 1/8 in. Slip	4350							
	Average Static Load	4133		6250		6900		6000	
Repeated Load Tests	Specimen Number	3B3	D2	3D6	F8	3D3	E4	3E4	F4
	Specific Gravity	.445	.519	.440	.527	.495	.453	.468	.541
	Percent of Moisture Content	13.5	13.5	11.8	11.3	12.0	13.5	12.2	11.3
	Number of Cycles for 1/4 in. Slip	107,000		250,000		>500,000		7000	
	Load	1800		3500		3500		4000	
	Percent of Average Static Load	43.4		56.0		50.7		66.7	
	Specimen Number	3H2	D3	3E2	F2	3D2	E2	3E5	F5
	Specific Gravity	.524	.487	.485	.542	.516	.536	.485	.606
	Percent of Moisture Content	12.5	12.2	13.2	13.0	11.3	12.2	10.9	12.0
	Number of Cycles for 1/4 in. Slip	64,000		32,000		75,000		>500,000	
	Load	2000		3750		4000		3750	
	Percent of Average Static Load	48.2		60.0		58.0		62.5	
	Specimen Number	3A3	D1					3F1	F6
	Specific Gravity	.479	.483					.609	.588
	Percent of Moisture Content	14.2	14.1					12.0	12.2
	Number of Cycles for 1/4 in. Slip	42,000						>500,000	
	Load	2200						4500	
	Percent of Average Static Load	53.0						75.0	

*With a 4 1/8 in. Single Curve Spike Grid

TABLE 5
BOLTED TIMBER JOINT STUDIES
TREATED DOUGLAS FIR
4 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.		1 in.	
		Sway	Pile	Sway	Pile	Sway	Pile
Static Tests	Specimen Number	4E3	D7	4D1	D1	4F1	D9
	Specific Gravity		.464	.587	.483	.546	.455
	Percent of Moisture Content	17.7	13.7	18.7	13.9	12.5	12.2
	Load at 1/8 in. Slip	4400		6200		7100	
	Specimen Number					4F4	E6
	Specific Gravity					.542	.532
	Percent of Moisture Content					14.0	12.0
	Load at 1/8 in. Slip					8000	
	Average Static Load	4400		6200		7550	
Repeated Load Tests	Specimen Number	4E4	D8	4D2	D2	4F2	D10
	Specific Gravity	.566	.439	.593	.519	.578	.494
	Percent of Moisture Content	14.0	11.3	16.0	10.2	11.5	10.0
	Number of Cycles for 1/4 in. Slip	>500,000		>500,000		123,000	
	Load	2000		3000		3500	
	Percent of Average Static Load	45.5		48.4		46.4	
	Specimen Number	4E1	D5	4D3	D3	4F3	E5
	Specific Gravity	.541	.491	.605	.487	.552	
	Percent of Moisture Content	12.9	11.6	14.2	10.8	11.7	11.3
	Number of Cycles for 1/4 in. Slip	74,000		250,000*		>500,000	
	Load	2500		3250		4000	
	Percent of Average Static Load	56.8		52.4		53.3	
	Specimen Number	4E2	D6	4D4	D4	4F5	E7
	Specific Gravity	.557	.492	.498	.507	.562	.478
	Percent of Moisture Content	13.9	11.9	14.6	10.6	10.0	10.8
	Number of Cycles for 1/4 in. Slip	11,000		>500,000		197,000	
	Load	3000		3500		4200	
	Percent of Average Static Load	68.2		56.5		55.6	

*Projected Value

TABLE 6
BOLTED TIMBER JOINT STUDIES
UNTREATED SOUTHERN PINE

3 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.		1 in.		3/4 in.**	
		Sway	Pile	Sway	Pile	Sway	Pile	Sway	Pile
Static Tests	Specimen Number	3A1	A1	3D1	D1	3E3	E3	3B3	B3
	Specific Gravity	.564	.618	.549	.547	.505	.596	.535	.564
	Percent of Moisture Content	22.9	28.3	13.8	11.6	19.0	20.5	19.0	16.8
	Load at 1/8 in. Slip	2350		3900		4400		9050	
	Specimen Number	3A3	A3	3D3	D3	3F1	F1	3C1	C1
	Specific Gravity	.564	.618	.549	.547	.598	.618		.614
	Percent of Moisture Content	23.1	23.5	14.5	11.1	14.5	8.5	15.5	18.0
	Load at 1/8 in. Slip	2800		5100		1050+		7400	
	Specimen Number	3B1	B1	3E1	E1	3F3	F3	3C3	C3
	Specific Gravity	.535	.564	.505	.596	.598	.618		.614
	Percent of Moisture Content	39.0	19.2	13.3	11.8	20.4	16.9	40.0	20.8
	Load at 1/8 in. Slip	3200		3700		3300+		8900	
	Average Static Load	2783		4233		4400		8450	
Repeated Load Tests	Specimen Number	3A2	A2	3D2	D2	3Z1	G1	3C2	C2
	Specific Gravity	.564	.618	.549	.547	.382	.464		.614
	Percent of Moisture Content	18.3	29.4	20.1	13.9	8.4	14.3	25.5	43.0
	Number of Cycles for 1/4 in. Slip	350,000		>500,000		350,000		>500,000	
	Load	1000		1600		2700		2800	
	Percent of Average Static Test	35.7		38.1		60.0		33.1	
	Specimen Number	3A4	A4	3Z2	E5	3Z4	F5	3B4	B4
	Specific Gravity	.564	.618	.382	.603	.382	.618	.535	.564
	Percent of Moisture Content	24.9	25.2	9.6	19.5	11.5	12.0	15.2	20.7
	Number of Cycles for 1/4 in. Slip	18,000		>500,000		163,000		>500,000	
	Load	1500		2000		2900		3700	
	Percent of Average Static Test	53.5		47.6		64.4		43.8	
	Specimen Number	3B2	B2	3Z3	D5	3F4	F4	3Y1	A5
	Specific Gravity	.535	.564	.382	.547	.598	616	.509	618
	Percent of Moisture Content	28.7	21.0	8.4	13.2	17.9	29.0		
	Number of Cycles for 1/4 in. Slip	7000		250,000		255,000		320,000	
	Load	2000		2400		2500		4250	
	Percent of Average Static Test	71.4		57.1		64.4		50.4	
	Specimen Number			3E2	E2	3F2	F2	3X1	C5
	Specific Gravity			.505	603	.598	.618	.587	.614
	Percent of Moisture Content			17.2	19.8	17.8	10.5	15.8	20.8
	Number of Cycles for 1/4 in. Slip			110,000		292,000*		100,000	
	Load			2800		3250		4600	
	Percent of Average Static Test			66.6		72.3		54.5	
	Specimen Number			3D4	D4	3E4	E4	3Y2	B5
	Specific Gravity			.549	547	.505	603	.509	.564
	Percent of Moisture Content			20.5	15.3	14.7	22.5	22.0	19.0
	Number of Cycles for 1/4 in. Slip			2000		16,000		75,000	
	Load			3200		3900		5000	
	Percent of Average Static Test			76.1		86.6		59.1	

*Projected Value
**With a 4 1/8 in. Single Curve Spike Grid
+ Not used in average

TABLE 7
BOLTED TIMBER JOINT STUDIES
UNTREATED SOUTHERN PINE
4 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.		1 in.	
		Sway	Pile	Sway	Pile	Sway	Pile
Static Tests	Specimen Number	4A1	A1	4B3	B3	4D1	D1
	Specific Gravity	.606	.476	.552	.466	.556	.630
	Percent of Moisture Content						
	Load at 1/8 in. Slip	3300		5400		7200	
	Specimen Number	4A3	A3	4C1	C1	4D3	D3
	Specific Gravity	.606	.476	.574	.460	.336	.630
	Percent of Moisture Content						
	Load at 1/8 in. Slip	3400		6700		6950	
	Specimen Number	4B1	B1	4C3	C3	4E1	E1
	Specific Gravity	.552	.466	.574	.640	.577	.560
	Percent of Moisture Content						
	Load at 1/8 in. Slip	2400		7500		6750	
	Average Static Load	3033		6533		6967	
Repeated Load Tests	Specimen Number	4A4	A4	4C2	C2	4E4	C5
	Specific Gravity	.606	.476	.574	.640	.577	.640
	Percent of Moisture Content	12.9	14.2	18.0	13.1		
	Number of Cycles for 1/4 in. Slip	>500,000		>500,000		> 500,000	
	Load	1600		2700		2800	
	Percent of Average Static Load	53.4		41.6		40.0	
	Specimen Number	4G3	D7	4C4	C4	4D2	D2
	Specific Gravity	.536	.630	.574	.640	.556	.630
	Percent of Moisture Content	10.9	10.9	16.5	12.0	15.9	14.6
	Number of Cycles for 1/4 in. Slip	365,000		178,000		123,000	
	Load	1700		3250		3900	
	Percent of Average Static Load	56.6		50.0		55.8	
	Specimen Number	4B2	B2	4F1	F1	4F4	F4
	Specific Gravity	.552	.466	.602	.454	.602	.454
	Percent of Moisture Content	17.7	14.6	14.0	22.2	13.0	37.0
	Number of Cycles for 1/4 in. Slip	33,000		145,000		94,000	
	Load	1800		3500		4400	
	Percent of Average Static Load	60.0		53.9		62.9	
	Specimen Number	4F2	A5	4F3	F3	4G1-S	B5
	Specific Gravity	.602	.476	.602	.454	.536	.466
	Percent of Moisture Content	12.5	16.2	16.5	19.8	10.8	19.0
	Number of Cycles for 1/4 in. Slip	72,000		103,000		5000	
	Load	1900		3700		4600	
	Percent of Average Static Load	63.4		56.9		65.7	
	Specimen Number	4A2	A2	4G2	B2	4D4	D4
	Specific Gravity	.606	.476	.536	.466	.556	.630
	Percent of Moisture Content	15.3	14.1	11.3	14.6	17.0	21.0
	Number of Cycles for 1/4 in. Slip	0		20,000		3000	
	Load	2000		3800		5000	
	Percent of Average Static Load	66.6		58.5		71.4	
	Specimen Number			4B4	B4		
	Specific Gravity			.552	.466		
	Percent of Moisture Content			21.8	15.0		
	Number of Cycles for 1/4 in. Slip			16,000			
	Load			3800			
	Percent of Average Static Load			58.5			

TABLE 8
BOLTED TIMBER JOINT STUDIES
TREATED SOUTHERN PINE
3 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.	1 in.	3/4 in.**	3/4 in.***
		Sway Pile	Sway Pile	Sway Pile	Sway Pile	Sway Pile	Sway Pile
Static Tests	Specimen Number	3A3 A3	3B1 B1	3F1 S1	3N1 O1	3B3 L1	3O2 AA6
	Specific Gravity		.473	.533 .529	.592 .466	.627	.523 .475
	Percent of Moisture Content	18.3 17.4	27.3 24.0	24.2 19.0	19.5 20.8	26.3 18.0	16.6 12.7
	Load at 1/8 in. Slip	3900	2700	3600	5250	7200	5300
	Specimen Number	3C1 E1	3A4 F3	3G1 T1	3H2 O4	3E1 A1	304 TX2
	Specific Gravity	.744	.576	.529 .531	.655 .519		.531 .520
	Percent of Moisture Content	20.8 17.4	21.9 22.5	27.4 17.6	19.9 22.9	14.8 19.0	15.0 13.8
	Load at 1/8 in. Slip	4100	4200	4300	5700	6200	2850
	Specimen Number	3L2 P2	3K2 Q2	3K4 R2		3D3 D2	3P4 AA4
	Specific Gravity	.528 .498	.654 .627	.623 .452		.464	.422 .503
	Percent of Moisture Content	21.3 24.5	22.5 22.5	20.8 19.6		20.6 26.1	14.8 14.8
	Load at 1/8 in. Slip	2750	3300	4850		6500	3700
	Specimen Number	3J2 Y2		3M4 R5		3D2 C2	3P2 AA2
	Specific Gravity	.483 .530		.651 .499		.454	.433 .533
	Percent of Moisture Content	19.6 19.8		16.6 16.7		20.5 20.5	15.5 14.3
	Load at 1/8 in. Slip	4100		4950		5000	5200
	Specimen Number					3E2 M1	
	Specific Gravity					.557	
	Percent of Moisture Content					15.8 27.9	
	Load at 1/8 in. Slip					5500	
	Average Static Load	3579		4425	5475	6080	4263
Repeated Load Tests	Specimen Number	3A2 A2	3J3 Y3	3J4 R1	3N2 O2	3D4 G2	3P3 AA3
	Specific Gravity		.560 .515	.521 .483	.665 .513	.455	.418 .544
	Percent of Moisture Content	11.7 16.7	18.0 18.5	15.2 14.0	12.3 15.2	17.5 15.7	13.3 13.5
	No. of Cycles for 1/4 in. Slip	>500,000	77,000	>500,000	290,000	>500,000	>500,000
	Load	1600	1800	1600	3000	3750	1800
	Percent of Ave. Static Load	44.4	50.0	36.0	54.6	61.5	42.4
	Specimen Number	3K1 Q1	3D1 C1	3G4 T4	3H3 O5	3C3 G3	3O3 TX1
	Specific Gravity	.653 .543	.513	.593 .527	.556 .555		.532 .445
	Percent of Moisture Content	16.1 17.1	17.7 17.6	21.7 18.0	18.1 21.0	17.4 17.3	13.1 9.7
	No. of Cycles for 1/4 in. Slip	96,000	15,000	193,000*	12,500	62,500*	85,000
	Load	1900	2000	1800	3250	3750	2200
	Percent of Ave. Static Load	52.8	55.5	40.4	59.1	61.5	51.8
	Specimen Number	3L3 P3	3C2 E2	3F2 S2	3H1 O3	3C4 G1	3P5 AA5
	Specific Gravity	.514 .580	.501	.590 .436	.517 .485	.673	.424 .528
	Percent of Moisture Content	22.8 20.9	43.0 19.2	21.1 16.0	18.2 19.1	19.2 15.0	11.9 11.4
	No. of Cycles for 1/4 in. Slip	4000	126,000	200,000	5000	118,000	390,000*
	Load	2000	2000	2000	3500	4500	2500
	Percent of Ave. Static Load	55.5	55.5	45.0	63.6	73.8	58.8
	Specimen Number	3B2 B2	3K3 Q3	3G3 T3		3B4 L2	3O1 AA7
	Specific Gravity	.455	.613 .543	.558 .491		.569	.591 .430
	Percent of Moisture Content	23.5 24.3	19.6 19.1	13.5 18.5		37.0 18.2	12.7 8.8
	No. of Cycles for 1/4 in. Slip	16,000	65,000*	35,000		500	>500,000
	Load	2000	2100	2200		5000	3000
	Percent of Ave. Static Load	55.5	58.4	49.5		82.0	70.6
	Specimen Number	3L1 P1	3J1 Y1	3M1 R3			3P1 AA1
	Specific Gravity	.575 .497	.431 .566	.557 .467			.452 .562
	Percent of Moisture Content	15.5 19.4	16.0 20.0	12.1 12.1			14.2 12.7
	No. of Cycles for 1/4 in. Slip	5000	28,000	>500,000			0
	Load	2200	2300	2400			3750
	Percent of Ave. Static Load	61.1	63.9	54.0			88.2
	Specimen Number	3A1 F1		3M3 R4			
	Specific Gravity	.646		.626 .475			
	Percent of Moisture Content	16.8 14.7		21.7 14.0			
	No. of Cycles for 1/4 in. Slip	200,000*		70,000			
	Load	2400		3250			
	Percent of Ave. Static Load	66.6		73.0			

*Projected Value
**With 4 1/8 in. Grid Joints
***With 4 1/8 in. Grid Joints, Spike Grid Half Seated

TABLE 9
BOLTED TIMBER JOINT STUDIES
TREATED SOUTHERN PINE
4 x 8 SWAY BRACES

	Bolt Size	3/4 in.		7/8 in.		1 in.	
		Sway	Pile	Sway	Pile	Sway	Pile
Static Tests	Specimen Number	4E4	BB7	4C4	U4	4C2	U2
	Specific Gravity	.586	.528	.659	.535	.637	.539
	Percent of Moisture Content	13.8	9.9	14.9	16.1	17.7	12.8
	Load at 1/8 in. Slip	3900		5550		6400	
	Specimen Number			4B2	W2	4A2	V2
	Specific Gravity			.631	.510	.737	.653
	Percent of Moisture Content			15.2	16.4	17.4	13.3
	Load at 1/8 in. Slip			5900		6250	
	Specimen Number			4D2	BB2	4E2	BB5
	Specific Gravity			.567	.505	.584	.499
	Percent of Moisture Content			19.1	19.8	21.4	21.4
	Load at 1/8 in. Slip			3800		6100	
	Average Static Load	3900		5083		6250	
Repeated Load Tests	Specimen Number	4E6	BB9	4D3	BB3	4C1	U1
	Specific Gravity	.580	.540	.587	.471	.632	.506
	Percent of Moisture Content	16.1	17.9	15.4	11.4	17.7	10.5
	Number of Cycles for 1/4 in. Slip	>500,000		450,000*		>500,000	
	Load	2000		2500		3500	
	Percent of Average Static Load	51.3		49.0		56.0	
	Specimen Number	4E5	BB8	4D1	BB1	4A1	V1
	Specific Gravity	.554	.495	.538	.485	.696	.594
	Percent of Moisture Content	24.7	21.3	17.7	17.4	13.0	10.9
	Number of Cycles for 1/4 in. Slip	23,000		4000		>500,000	
	Load	2500		3000		3800	
	Percent of Average Static Load	64.1		58.9		60.8	
	Specimen Number	4E3	BB6	4B3	W3	4A3	V3
	Specific Gravity	.527	.521	.666	.469	.601	.675
	Percent of Moisture Content	20.6	24.9	18.1	15.1	13.0	11.4
	Number of Cycles for 1/4 in. Slip	12,000		235,000*		215,000*	
	Load	3000		3000		4000	
	Percent of Average Static Load	76.9		58.9		64.0	
	Specimen Number			4B1	W1	4E1	BB3
	Specific Gravity			.609	.498	.593	.530
	Percent of Moisture Content			15.8	12.2	13.5	16.6
	Number of Cycles for 1/4 in. Slip			52,000		10,000	
	Load			3250		4200	
	Percent of Average Static Load			63.7		67.2	
	Specimen Number			4C3	U3		
	Specific Gravity			.642			
	Percent of Moisture Content			14.1			
	Number of Cycles for 1/4 in Slip			21,000			
	Load			3500			
	Percent of Average Static Load			68.6			

*Projected Value

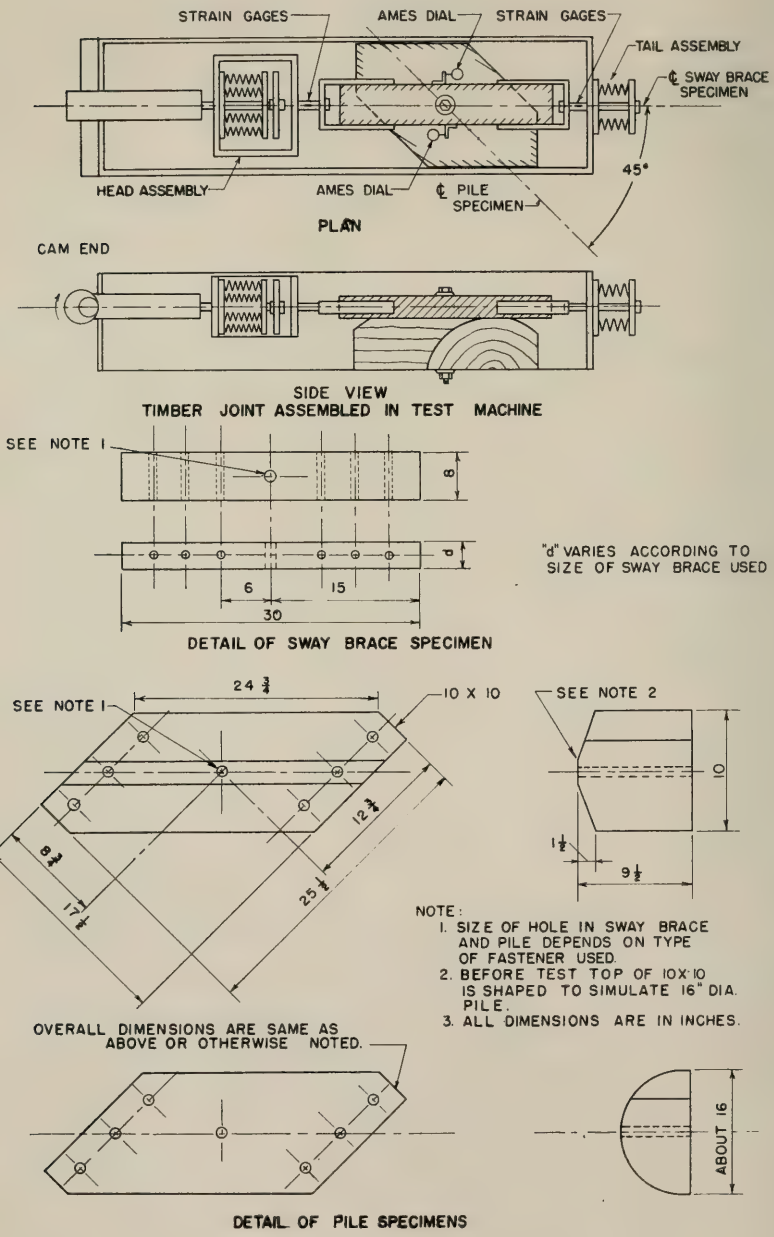
TABLE 10
SUMMARY OF RESULTS OF STATIC AND REPEATED LOAD TESTS
BOLTED TIMBER JOINT STUDIES

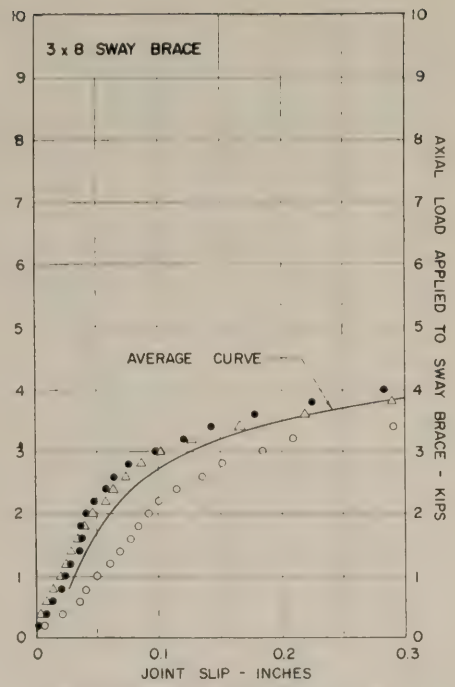
Specie & Treatment	Size of Sway Brace	Fastener	Static Tests			Repeated Load Tests				
			Load at 1/8" Slip	Average Specific Gravity	Average Moisture Content	Estimated Load for 1/4" Slip At 500,000 Cy.	Average Specific Gravity	Average Moisture Content	Percent of Average Static Load	
1	2	3	4	5	6	7	8	9	10	11
Untreated Douglas Fir	3 x 8	3/4" Bolt	3000	.495	26.3	1000	.495	23.1	33	38
		7/8"	4500	.496	17.5	1200	.484	14.0	27	
		1"	5200	.503	13.8	1800	.509	11.5	35	
		1 1/4"	6650	.442	12.5	3500	.453	9.5	52	
		3/4" Bolt & 4 1/8" Grid	7450	.484	16.1	3200	.491	19.1	43	
	4 x 8	3/4" Bolt	2650	.520	18.4	1000	.520	13.9	38	43
		7/8"	4600	.488	13.0	2000	.517	11.8	44	
		1"	6400	.471	11.3	2800	.471	11.3	44	
		1 1/4"	9200	.527	10.4	4200	.527	9.5	46	
Treated Douglas Fir	3 x 8	3/4" Bolt	4150	.495	13.1	1400	.489	13.3	34	51
		7/8"	6250	.480	12.2	3200	.498	12.3	51	
		1"	6900	.475	12.7	3800	.500	12.3	55	
		3/4" Bolt & 4 1/8" Grid	6000	.551	13.9	3900	.550	11.8	65	
	4 x 8	3/4" Bolt	4400	.464	15.7	2200	.514	12.6	50	51
		7/8"	6200	.535	16.0	3100	.552	12.7	50	
		1"	7550	.519	12.7	4100	.533	10.9	54	
Untreated Southern Pine	3 x 8	3/4" Bolt	2800	.577	26.0	800	.577	24.6	29	46
		7/8"	4200	.549	12.7	2200	.521	15.8	52	
		1"	4500	.589	16.6	2600	.539	15.9	58	
		3/4" Bolt & 4 1/8" Grid	8450	.582	21.7	3900	.568	22.8	46	
	4 x 8	3/4" Bolt	3000	.530		1600	.543	13.9	53	48
		7/8"	6500	.544		2900	.547	16.2	37	
		1"	7000	.548		3300	.565	18.5	47	
Treated Southern Pine	3 x 8	3/4" Bolt	3600	.568	21.5	1800	.544	19.5	50	54
		7/8"	4450	.543	20.2	2000	.527	16.5	45	
		1"	5500	.558	20.8	2800	.549	17.3	51	
		3/4" Bolt & 4 1/8" Grid	6100	.526	21.0	4100	.566	19.7	67	
		3/4" Bolt & 4 1/8" Grid*	4250	.492	14.7	2500	.493	12.1	59	
	4 x 8	3/4" Bolt	3900	.557	11.9	2100	.536	20.9	54	55
		7/8"	5100	.568	16.9	2500	.552	15.2	49	
		1"	6250	.608	17.3	3900	.603	13.3	62	

*Spike Grid Half Seated

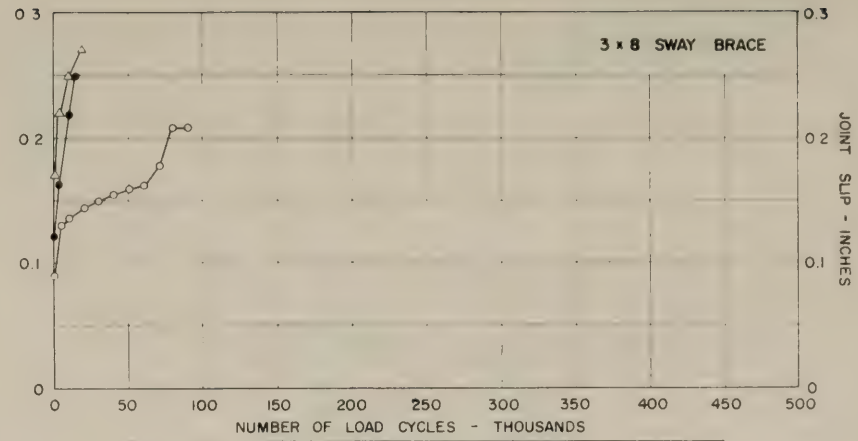
A

FIG. 1
BOLTED TIMBER JOINT STUDIES
ASSEMBLY AND DETAILS OF TEST SPECIMENS





STATIC TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	F-3A1	0.528	28.7	F-A1	0.452	34.1
●	F-3A3	0.528	27.0	F-A3	0.452	26.9
△	F-3B1	0.501	20.4	F-B1	0.508	20.6

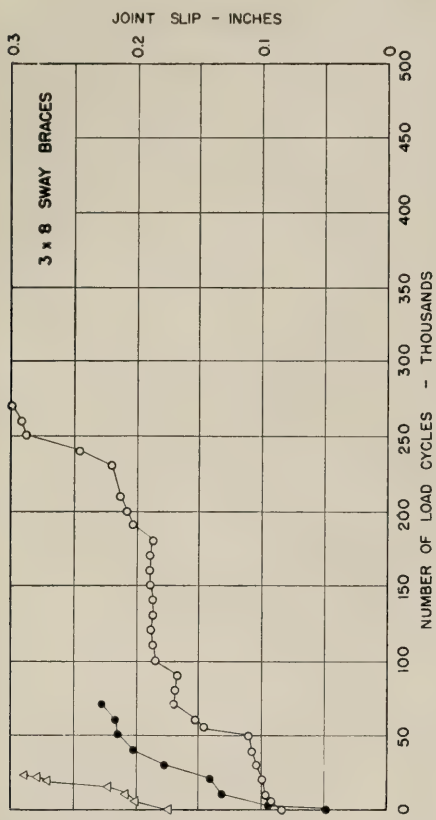


REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
○	F-3B2	0.501	17.0	F-B2	0.508	20.3	1200
●	F-3A4	0.528	——	F-A4	0.452	——	1500
△	F-3A2	0.528	25.9	F-A2	0.452	29.3	1500

NOTE. A $\frac{3}{4}\phi$ MACHINE BOLT WAS USED WITH TWO O.G WASHERS

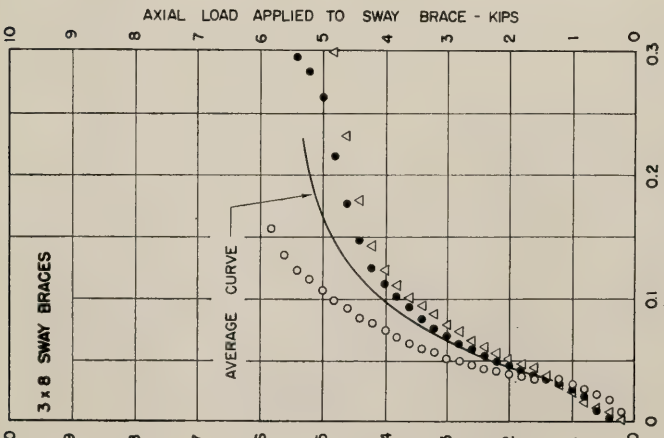
FIG 2

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{3}{4}$ BOLTS
UNTREATED DOUGLAS FIR



SYMBOLS	REPEATED LOAD TESTS						
	SWAY			PILE			
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
○	F-3B4	0.501	10.9	F-B4	0.508	13.0	1400
●	F-3C2	0.462	14.0	F-C2	0.520	19.5	2100
△	F-3C4	0.462	11.5	F-A5	0.452	15.2	3150

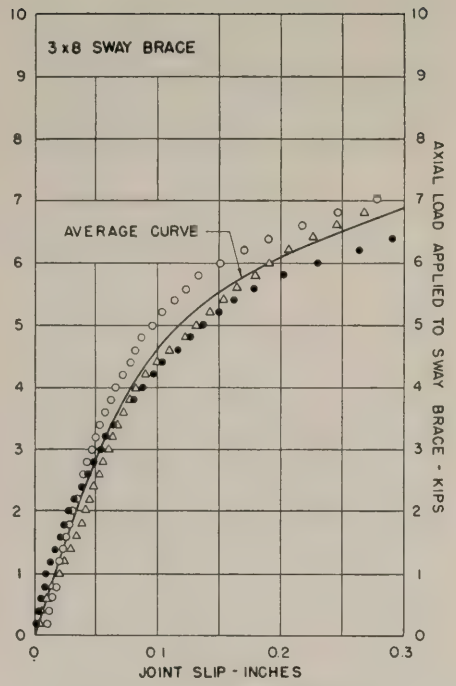
NOTE: A $\frac{7}{8}\phi$ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS

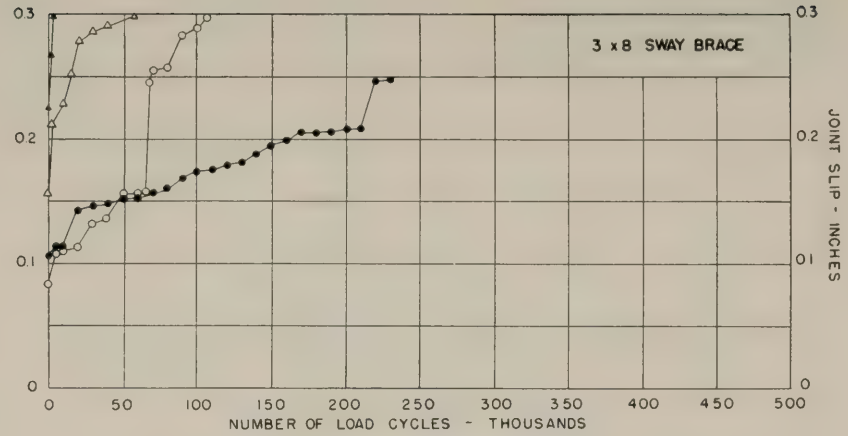


SYMBOLS	STATIC TESTS					
	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	F-3C1	0.462	13.4	F-C1	0.520	17.0
●	F-3C3	0.462	16.3	F-C3	0.520	21.0
△	F-3B3	0.501	16.5	F-B3	0.508	20.8

FIG. 3

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS-$\frac{7}{8}$ BOLTS
UNTREATED DOUGLAS FIR



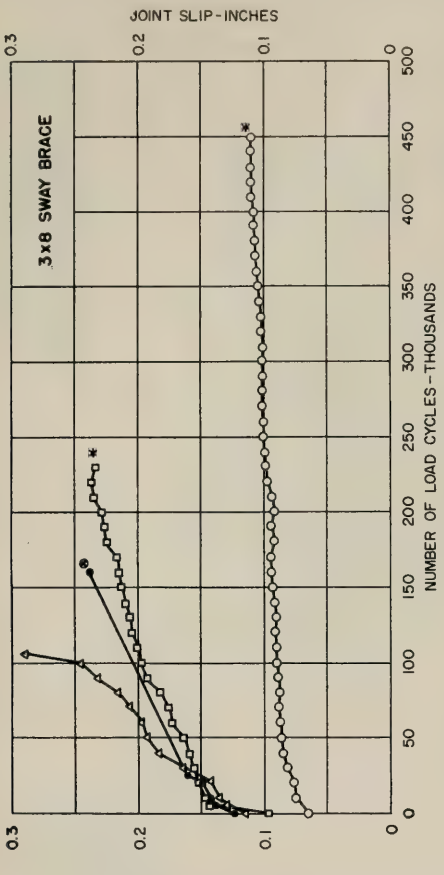


STATIC TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	F-3D1	0.582	12.4	F- D1	0.434	13.7
●	F-3D3	0.582	13.3	F- D3	0.434	16.1
△	F-3E1	0.549	13.8	F- 1	0.449	13.3

REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
●	F-3X1	0 514	9 0	F- B5*	0 526	9 0	2000
○	F-3E2	0 549	11 8	F- E2	0 449	11.3	2000
△	F-3D4	0 582	11 6	F- D4	0 434	12 9	3250
▲	F-3D2	0.582	12.2	F- D2	0 434	13.9	4500

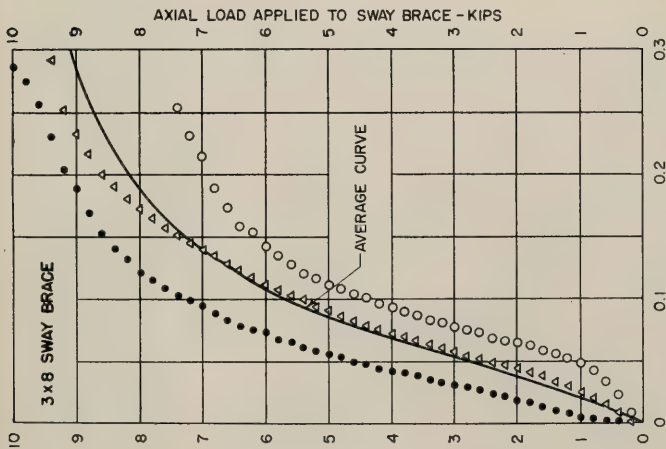
NOTE:
A 1 ϕ MACHINE BOLT WAS USED WITH TWO O.G WASHERS
* WITH $\frac{1}{2}$" SHIM

FIG. 4
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1 BOLTS
UNTREATED DOUGLAS FIR



REPEATED LOAD TESTS							
SYMBOLS	SWAY			PILE			LOAD LBS.
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
○	F-3F2	0.432	9.5	F- F2	0.396	8.7	2400
●	F-3F4	0.432	9.5	F- F4	0.396	9.9	3900
□	F-3E4	0.549	9.3	F- E4	0.449	10.2	3900
△	F-3X2	0.514		F- F5+			4800

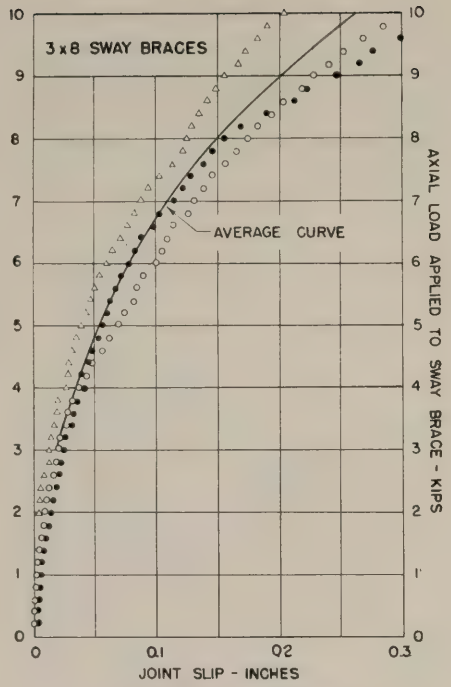
NOTE:
A $1\frac{1}{4}\phi$ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS.
* MACHINE FAILURE
● NO DATA TAKEN BETWEEN 25,000 & 160,000 CYCLES.
\+ PILE WITH $\frac{1}{2}$ SHIM



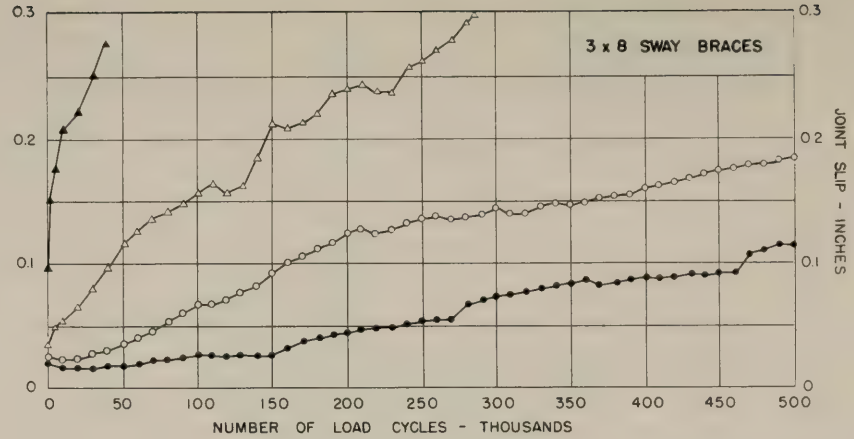
STATIC TESTS						
SYMBOLS	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	F-3E3	0.549	9.9	F- E3	0.449	10.9
●	F-3F1	0.432	17.0	F- F1	0.396	19.0
△	F-3F3	0.432	9.3	F- F3	0.396	8.9

FIG. 5

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS-$1\frac{1}{4}$ BOLTS
UNTREATED DOUGLAS FIR



STATIC TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
●	F-3G1	0.503	15.0	F- G3	0.462	16.9
○	F-3G2	0.503	15.4	F- G5	0.462	17.0
△	F-3G3	0.503	15.3	F- H1	0.472	17.2

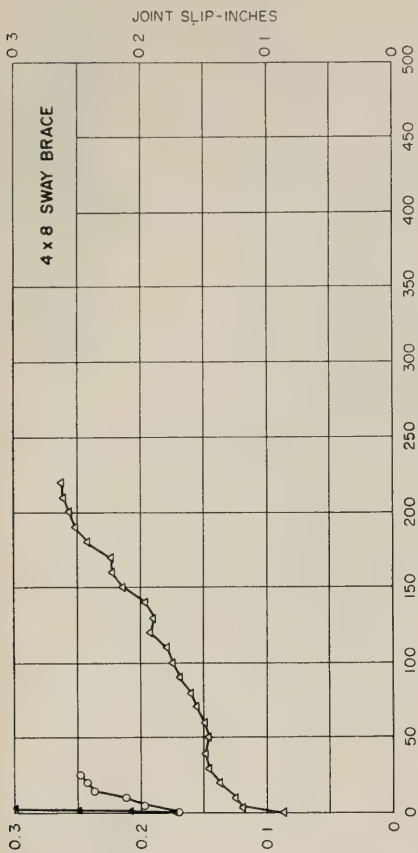


REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
●	F-3G4	0.503	17.6	F- H2	0.472	18.6	1840
○	F-3H2	0.513	21.8	F- H4	0.472	19.6	2760
△	F-3H1	0.513	——	F- H3	0.472	19.0	3680
▲	F-3H3	0.513	19.0	F- H5	0.472	18.3	4600

NOTE: A $\frac{3}{4}\phi$ BOLT WAS USED WITH A $4\frac{1}{8}$ IN SINGLE CURVE SPIKE GRID. (FULLY SEATED)

FIG. 6

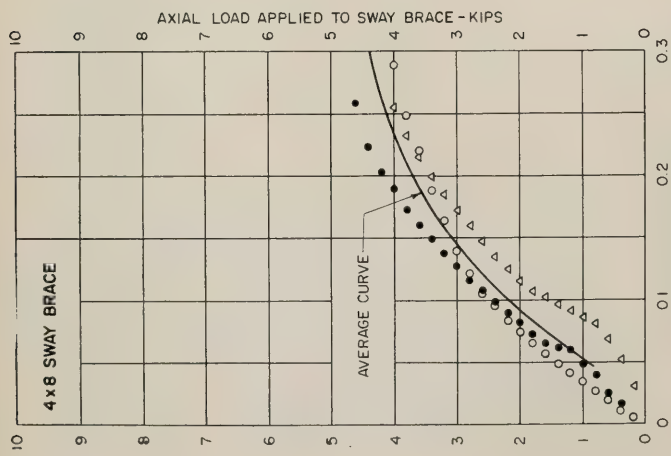
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
$\frac{3}{4}$ BOLT AND $4\frac{1}{8}$ GRID JOINTS
UNTREATED DOUGLAS FIR



SYMBOLS	SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS.
△	F-4A4	0.502	13.4	F-A4	0.544	15.5	1200
○	F-4A2	0.502	13.0	F-A2	0.544	16.7	1950
▲	F-4A6	0.502	10.6	F-B2	0.526	14.0	2700

REPEATED LOAD TESTS

NOTE. A $\frac{3}{4}\phi$ MACHINE BOLT WAS USED WITH TWO O.G WASHERS

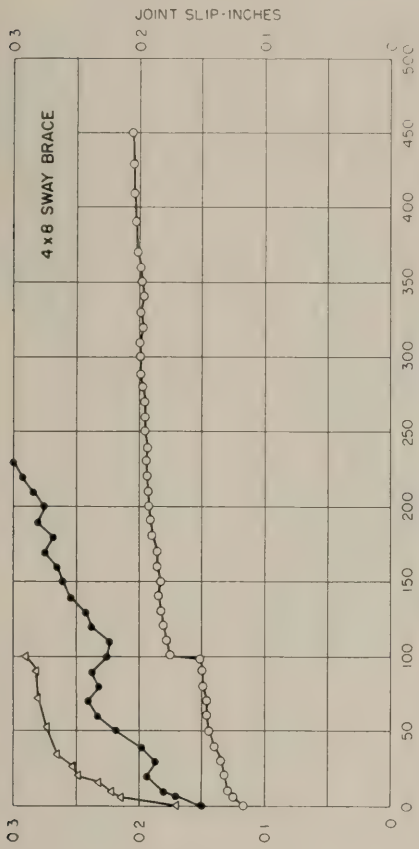


SYMBOLS	SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
○	F-4A1	0.502	11.8	F-A1	0.544	17.7
●	F-4A3	0.502	10.5	F-A3	0.544	15.3
△	F-4A5	0.502	9.7	F-B1	0.526	15.1

STATIC TESTS

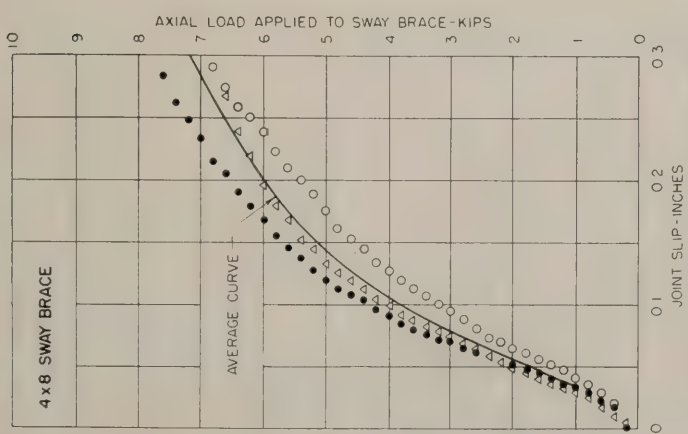
FIG. 7

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{3}{4}$ BOLTS
UNTREATED DOUGLAS FIR



SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
○	F-4B2	0.472	12.1	F-B4	0.526	13.7	1680
●	F-4D7	0.564	8.7	F-A5	0.544		2730
△	F-4A7	0.502	12.3	F-C4	0.493	12.3	3780

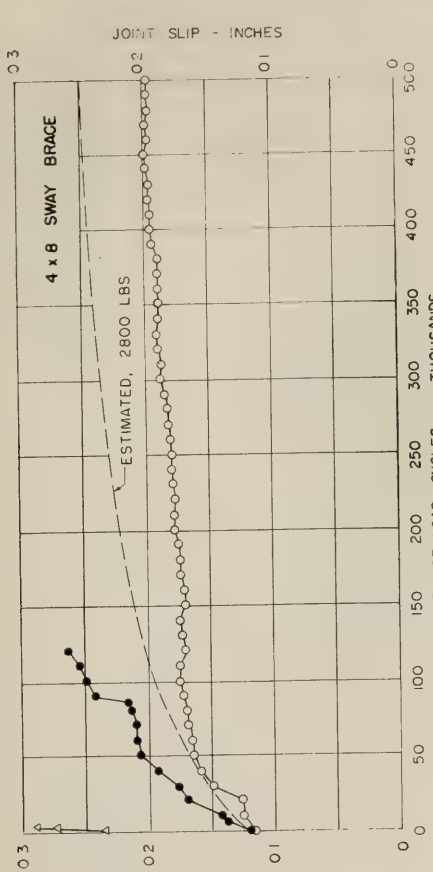
NOTE △ $\frac{7}{8}\phi$ MACHINE BOLT WAS USED WITH TWO OG WASHERS



SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	F-4B1	0.472	13.1	F-C1	0.493	13.3
●	F-4B3	0.472	12.0	F-C3	0.493	13.0
△	F-4B5	0.472	12.0	F-B3	0.526	14.4

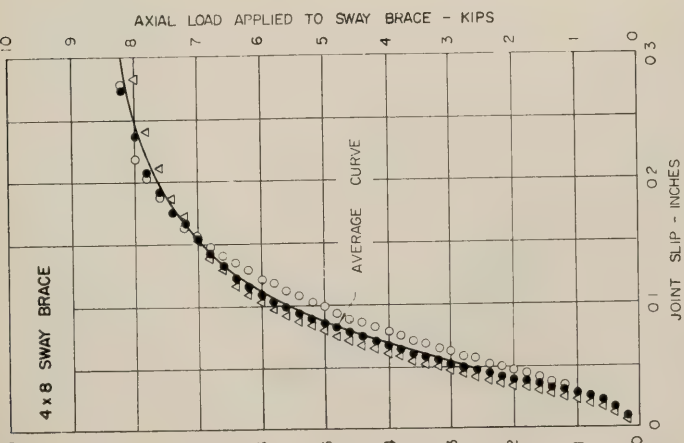
FIG. 8.

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS-$\frac{7}{8}$ BOLTS
UNTREATED DOUGLAS FIR



REPEATED LOAD TESTS							
SYMBOLS	SWAY			PILE			
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
○	F-4C2	0.512	10.6	F-D2	0.438	10.5	2400
●	F-4C4	0.512	11.7	F-D4	0.438	11.3	3900
△	F-4C6	0.512	12.1	F-E2	0.414	11.3	5400

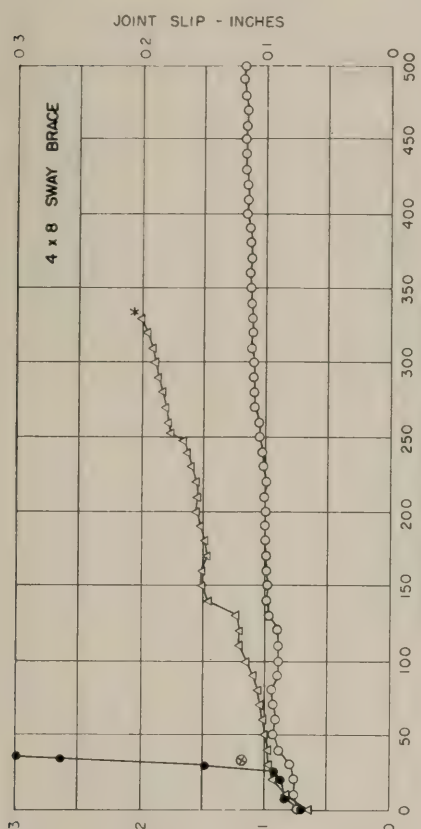
NOTE A 1 ϕ MACHINE BOLT WAS USED WITH TWO OG WASHERS



STATIC TESTS						
SYMBOLS	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	F-4C1	0.512	14.0	F-D1	0.438	10.3
●	F-4C3	0.512	10.8	F-D3	0.438	10.2
△	F-4C5	0.512	11.5	F-E1	0.414	10.8

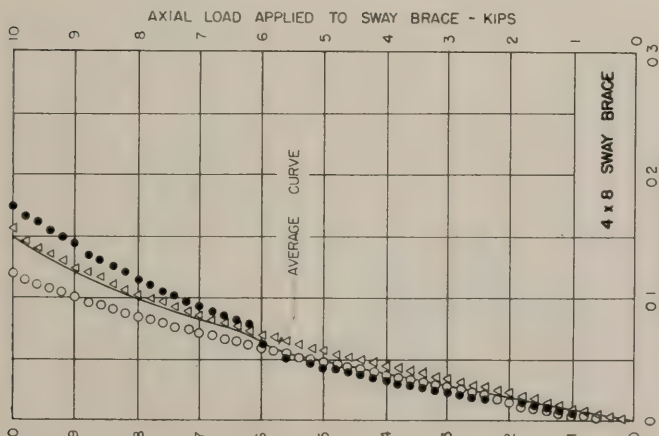
FIG. 9

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1 BOLTS
UNTREATED DOUGLAS FIR



SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
●	F-4D2	0.564	9.0	F- F2		10.6	3000
○	F-4D6	0.564		F- E4	0.414	9.5	3200
△	F-4D4	0.564	8.5	F- F4		9.8	4200

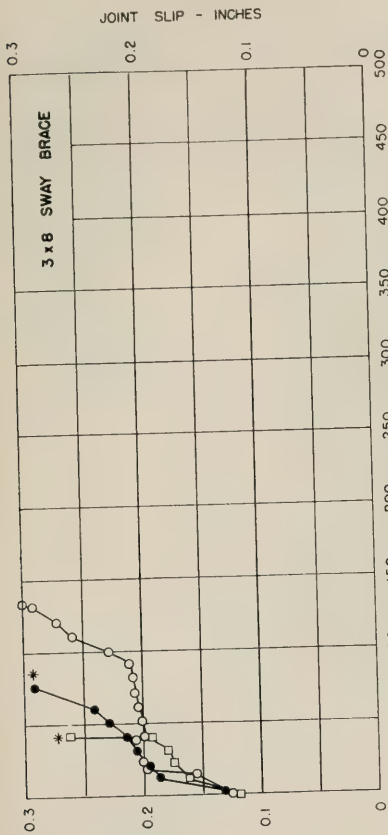
NOTE
△ 1¼ϕ MACHINE BOLT WAS USED WITH TWO OG WASHERS
✶ MACHINE FAILURE
⊗ THE PILE CHECKED THROUGH THE BOLT HOLE



SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
●	F-4D1	0.564	9.6	F- F1		13.0
○	F-4D3	0.564	9.8	F- F3		10.7
△	F-4D5	0.564	9.6	F- E3	0.414	9.5

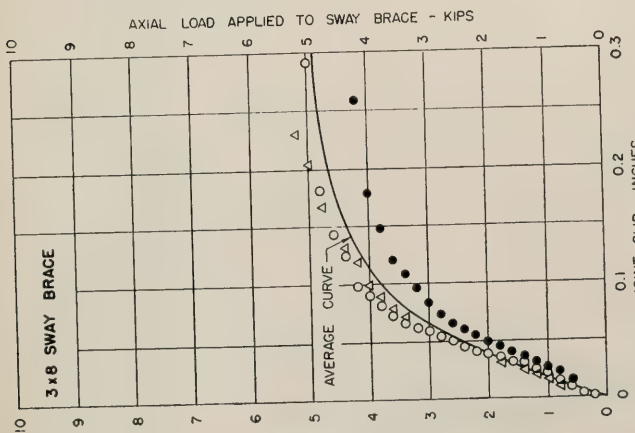
FIG. 10

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1¼ BOLTS
UNTREATED DOUGLAS FIR



SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS
○	TF-3B3	0.445	13.5	TF-D2	0.519	13.5	1800
●	TF-3A2	0.524	12.5	TF-D3	0.487	12.2	2000
□	TF-3A3	0.479	14.2	TF-D1	0.483	14.1	2200

NOTE: A $\frac{3}{4}\phi$ MACHINE BOLT WAS USED WITH TWO O.G WASHERS.
✱ BOLT BROKE.



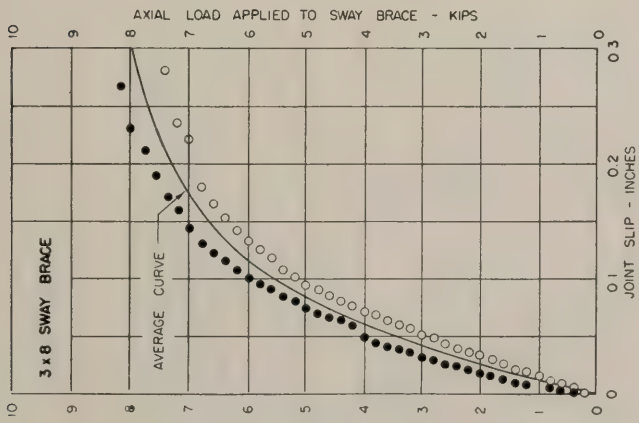
SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
○	TF-C4		12.1	TF-B2	0.463	13.8
●	TF-C2		13.0	TF-B1	0.498	13.7
△	TF-C3		13.0	TF-A1	0.525	12.9

FIG. 11
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{3}{4}$ BOLTS
TREATED DOUGLAS FIR

REPEATED LOAD TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
○	TF-3D6	0.440	11.8	TF-F9	0.527	11.3	3500
●	TF-3E2	0.485	13.2	TF-F2	0.542	13.0	3750

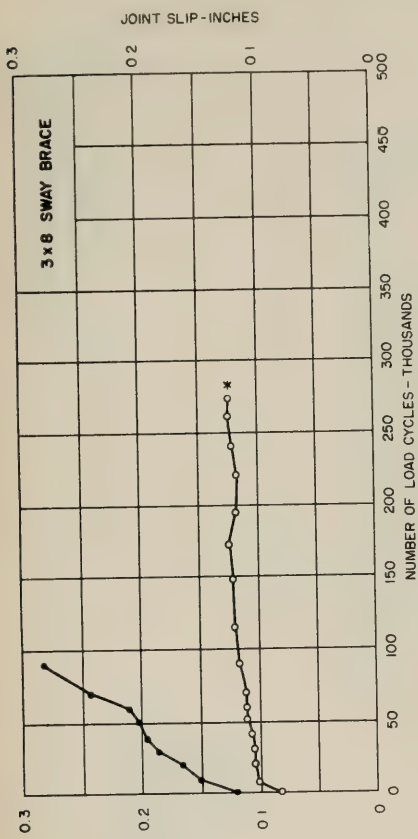
NOTE: A $\frac{7}{8}$" MACHINE BOLT WAS USED WITH TWO OG WASHERS

✱ BOLT BROKE.



STATIC TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TF-3D4	0.446	12.5	TF-F7	0.526	12.2
●	TF-3E1	0.491	11.8	TF-E1	0.458	12.3

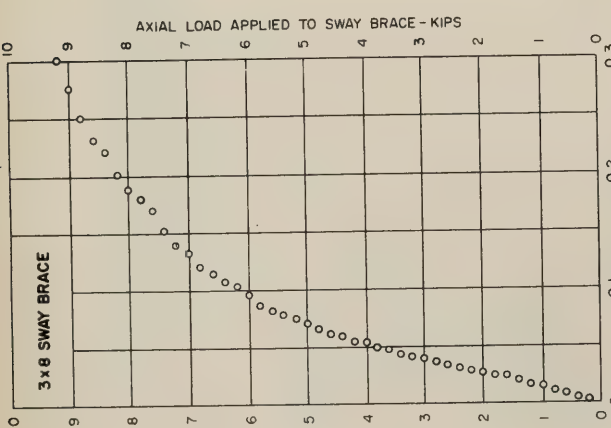
FIG. 12
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{7}{8}$" BOLTS
TREATED DOUGLAS FIR



SYMBOLS	SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS.
REPEATED LOAD TESTS							
○	TF-3D3	0.495	12.0	TF-E4	0.453	13.5	3500
●	TF-3D2	0.516	11.3	TF-E2	0.536	12.2	4000

NOTE: A 1" ϕ MACHINE BOLT WAS USED WITH TWO OG WASHERS

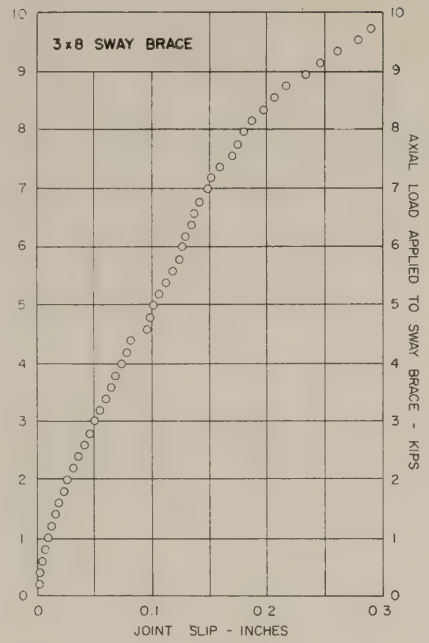
* BOLT BROKE

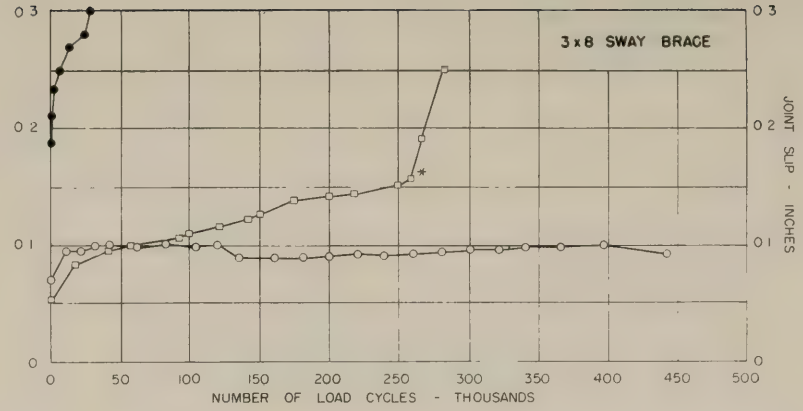


SYMBOLS	SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
STATIC TESTS						
○	TF-3D1	0.493	12.3	TF-E3	0.457	13.0

FIG. 13

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS-1 BOLTS
TREATED DOUGLAS FIR





	STATIC TESTS						
	SYMBOLS	SWAY			PILE		
		SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
a	○	TF-3E3	0.542	12.2	TF-F3	0.561	15.6

	REPEATED LOAD TESTS							
	SYMBOLS	SWAY			PILE			LOAD LBS
		SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
b	●	TF-3E4	0.468	12.2	TF-F4	0.541	11.3	4000
c	○	TF-3E5	0.485	10.9	TF-F5	0.606	12.0	3750
d	□	TF-3F1	0.609	12.0	TF F6	0.588	12.0	4500

NOTE:

A $\frac{3}{4}$ Φ BOLT WAS USED WITH A $4\frac{1}{8}$ IN SINGLE CURVE SPIKE GRID (FULLY SEATED)

a_ GRID SEATED AT LOAD OF 23,000 LBS

b_ GRID SEATED AT LOAD OF 24,000 LBS

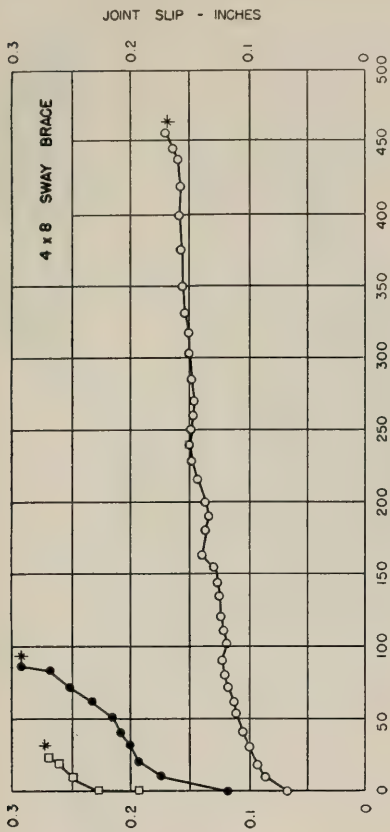
c_ GRID SEATED AT LOAD OF 19,000 LBS

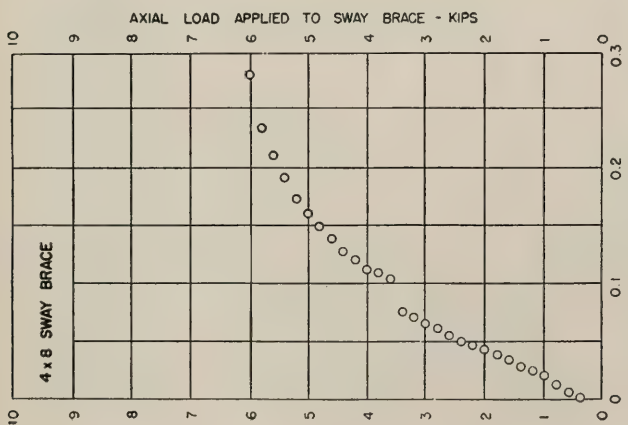
d_ GRID SEATED AT LOAD OF 25,000 LBS

*_ BOLT BROKE

FIG. 14

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
$\frac{3}{4}$ BOLT AND $4\frac{1}{8}$ GRID JOINTS
TREATED DOUGLAS FIR





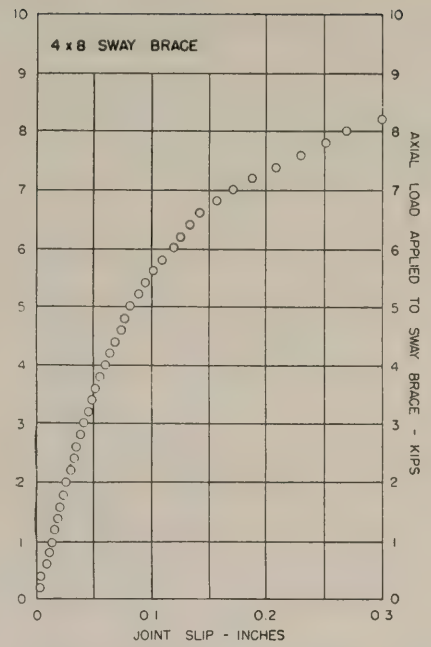
REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
○	TF-4E4	0.566	14.0	TF-D8	0.439	11.3	2000
●	TF-4E1	0.541	12.9	TF-D5	0.491	11.6	2500
□	TF-4E2	0.573	13.9	TF-D6	0.492	11.9	3000

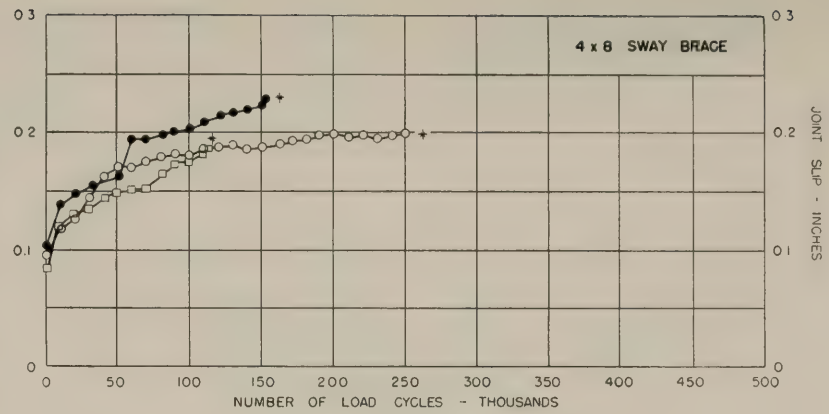
NOTE: A $\frac{3}{4}\phi$ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS.
✱ BOLT BROKE.

STATIC TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
○	TF-4E3		17.7	TF-D7	0.464	13.7	

FIG. 15

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{3}{4}$ BOLTS
TREATED DOUGLAS FIR





STATIC TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TF - 4D1	0.587	18.1	TF - D1	0.483	13.9

REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
○	TF - 4D2	0.593	16.0	TF - D2	0.519	10.2	3000
●	TF - 4D3	0.605	14.2	TF - D3	0.487	10.8	3250
▢	TF - 4D4	0.498	14.6	TF - D4	0.507	10.6	3500

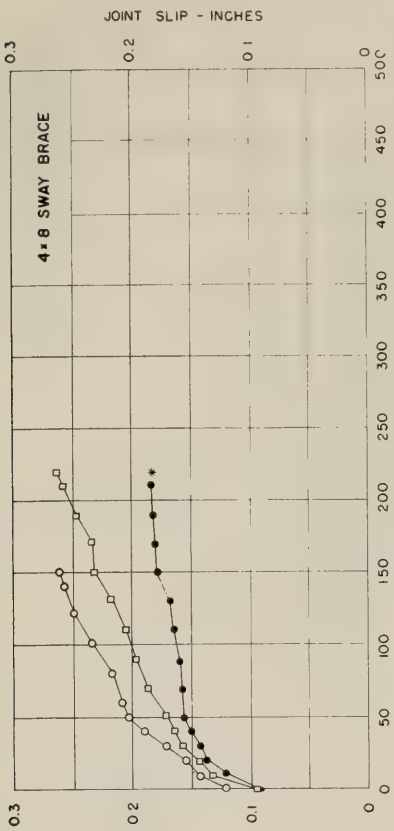
NOTE

A $\frac{7}{8}\phi$ MACHINE BOLT WAS USED WITH TWO 0.6 WASHERS

✳ BOLT BROKE

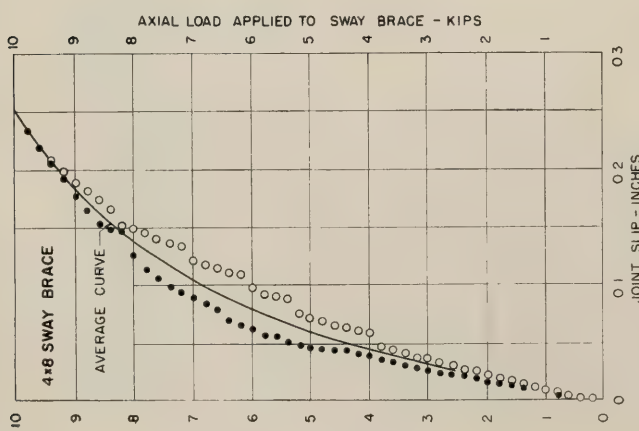
FIG. 16

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{7}{8}$ BOLTS
TREATED DOUGLAS FIR



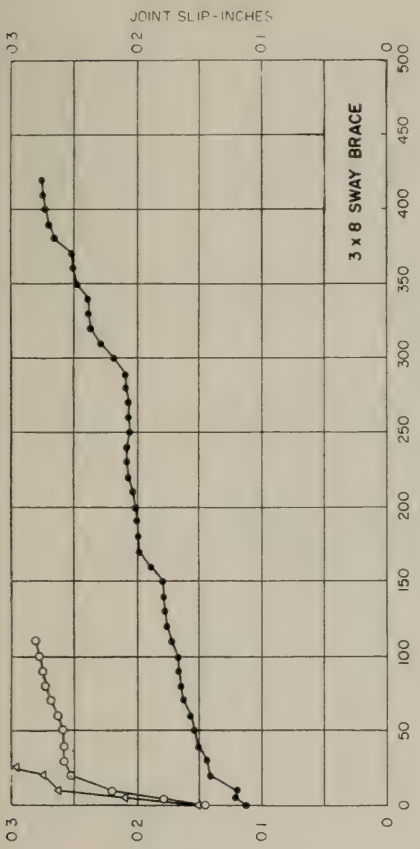
SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS.
○	TF-4F2	0.578	11.5	TF-D10	0.494	10.0	3500
●	TF-4F3	0.552	11.7	TF-E5		11.3	4000
□	TF-4F5	0.562	10.0	TF-E7	0.478	10.8	4200

NOTE: A 1 ϕ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS
* BOLT BROKE



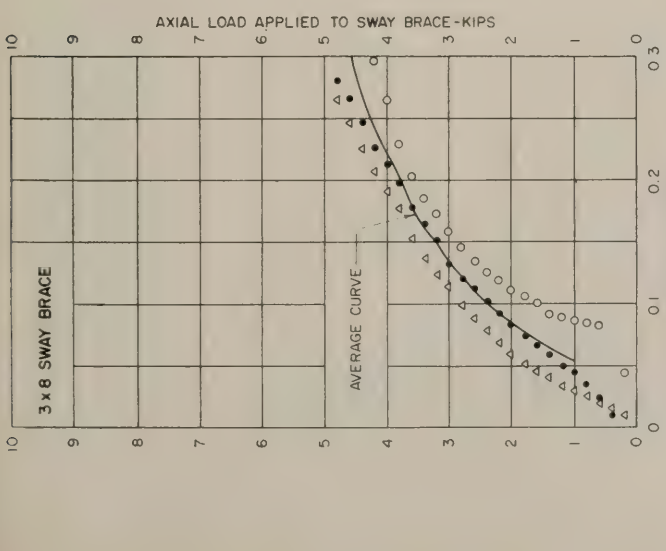
	STATIC TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
○	TF-4F1	0.546	12.5	TF-D9	0.455	12.2
●	TF-4F4	0.542	14.0	TF-E6	0.532	12.0

FIG. 17
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1 BOLTS
TREATED DOUGLAS FIR



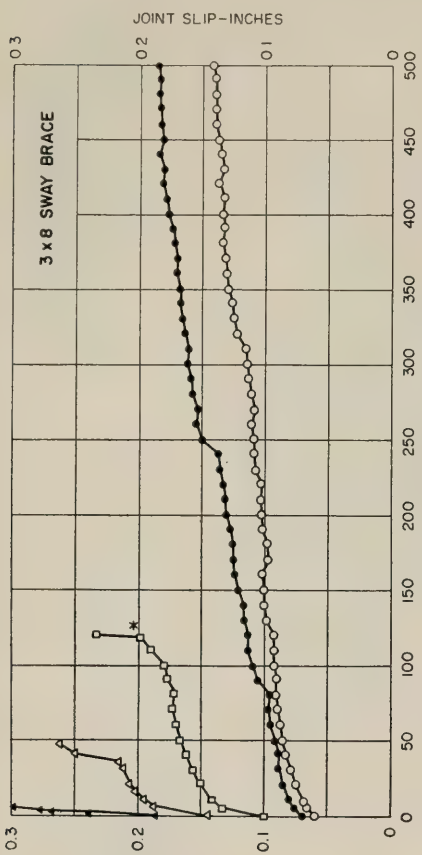
SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
●	P-3A2	0.564	18.3	P- A2	0.618	29.4	1000
○	P-3A4	0.564	24.9	P- A4	0.618	25.2	1500
△	P-3B2	0.535	28.7	P- B2	0.564	21.0	2000

NOTE. A $\frac{3}{4}\phi$ MACHINE BOLT WAS USED WITH TWO OG WASHERS



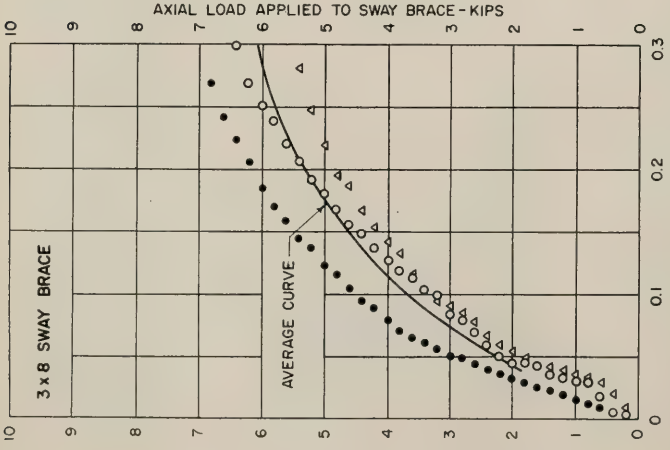
SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	P-3A1	0.564	22.9	P- A1	0.618	28.3
●	P-3A3	0.564	23.1	P- A3	0.618	23.5
△	P-3B1	0.535	39.0	P- B1	0.564	19.2

FIG 18
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS-$\frac{3}{4}$ BOLTS
UNTREATED SOUTHERN PINE



REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
●	P-3D2	0.549	20.1	P- D2	0.547	13.9	1600
○	P-3Z2	0.382	9.6	P- E5	0.603	19.5	2000
□	P-3Z3	0.382	8.4	P- D5	0.547	13.2	2400
△	P-3E2	0.505	17.2	P- E2	0.603	19.8	2800
▲	P-3D4	0.549	20.5	P- D4	0.547	15.3	3200

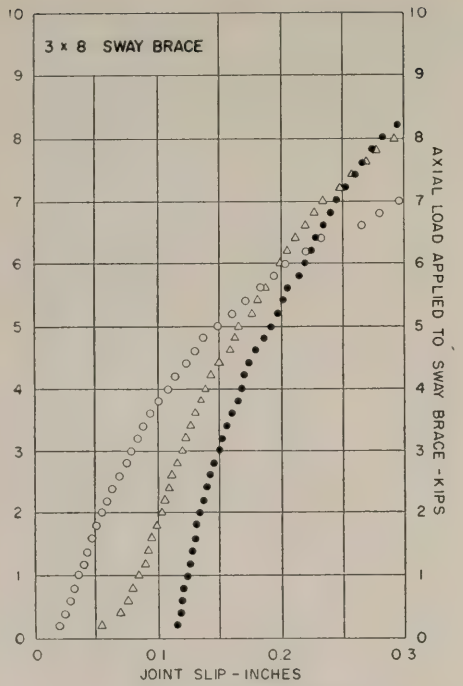
NOTE A $\frac{7}{8}\phi$ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS.
* BOLT BROKE

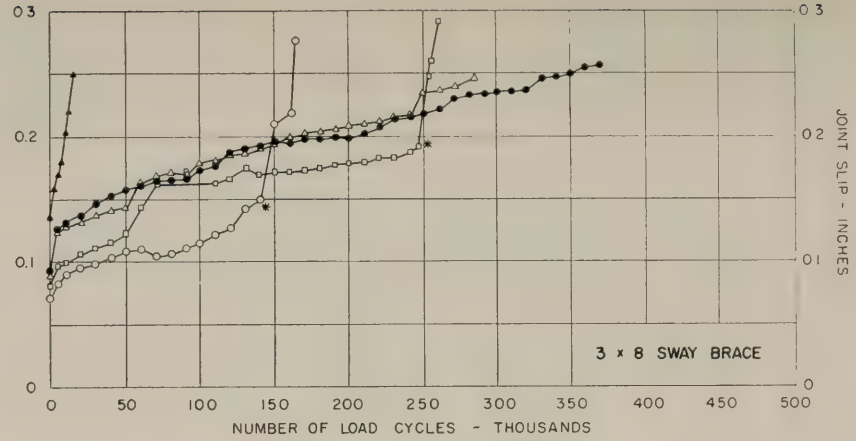


STATIC TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
□	P-3D1	0.549	13.8	P- D1	0.547	11.6	
●	P-3D3	0.549	14.5	P- D3	0.547	11.1	
△	P-3E1	0.505	13.3	P- E1	0.596	11.8	

FIG. 19

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{7}{8}$ BOLTS
UNTREATED SOUTHERN PINE





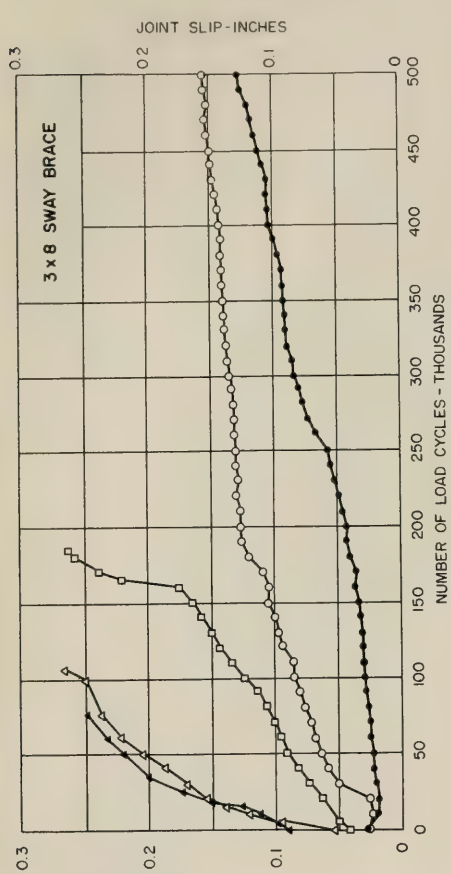
STATIC TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	P-3E3	0.505	19.0	P- E3	0.596	20.5
●	P-3F1	0.598	14.5	P- F1	0.618	8.5
△	P-3F3	0 598	20.4	P- F3	0.618	16.9

REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
●	P-3Z1	0.382	8 4	P- G1	0 464	14 3	2700
○	P-3Z4	0.382	11 5	P- F5	0.618	12 0	2900
□	P-3F4	0.598	17.9	P- F4	0.618	29 0	2900
△	P-3F2	0.598	17.8	P- F2	0.618	10.5	3250
▲	P-3E4	0.505	14.9	P- E4	0.603	22.5	3900

NOTE. A 1φ MACHINE BOLT WAS USED WITH TWO 0.G WASHERS
* A LARGE CHECK OPENED IN THE PILE

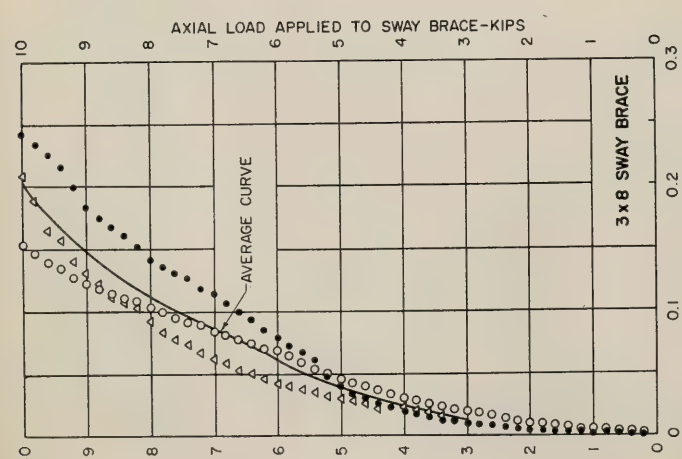
FIG. 20

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1 BOLTS
UNTREATED SOUTHERN PINE



SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS.
●	P-3C2		25 5	P- C2	0.614	43.0	2800
○	P-3B4	0.535	15.2	P- B4	0.564	20 7	3700
□	P-3Y1	0.509		P- A5	0.618		4250
△	P-3X1	0.587	15.8	P- C5	0.614	20 8	4600
■	P-3Y2	0.509	22.0	P- B5	0.564	19.0	5000

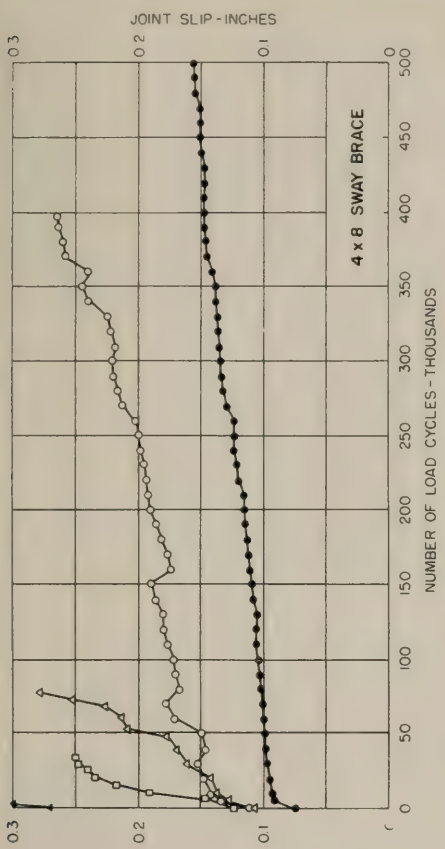
NOTE: A $\frac{3}{4}\phi$ BOLT WAS USED WITH A $4\frac{1}{8}$ IN SINGLE CURVE SPIKE GRID. (FULLY SEATED)



SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
○	P-3B3	0.535	19.0	P- B3	0.564	16.8
●	P-3C1		15.5	P- C1	0.614	18.0
△	P-3C3		40.0	P- C3	0.614	20.8

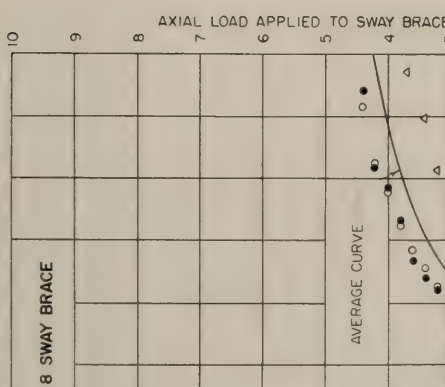
FIG. 21

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
$\frac{3}{4}$ BOLT AND $4\frac{1}{8}$ GRID JOINTS
UNTREATED SOUTHERN PINE



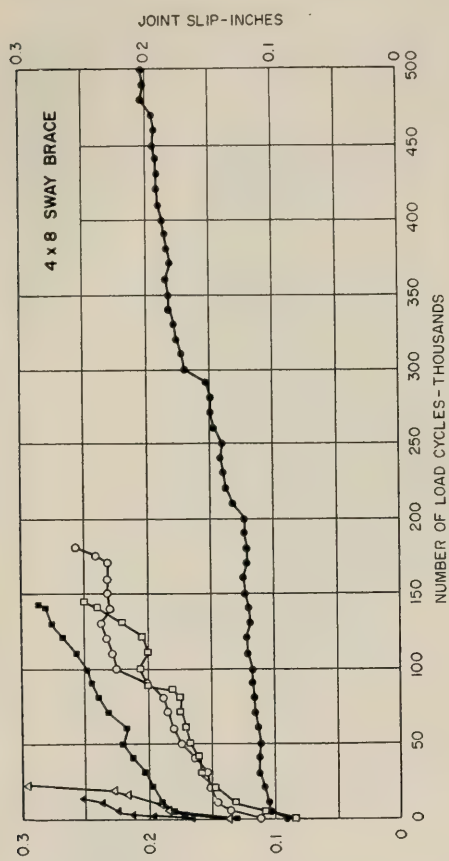
SYMBOLS	SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS.
	REPEATED LOAD TESTS						
●	P-4A4	0.606	12.9	P- A4	0.476	14.2	1600
○	P-4G3	0.536	10.9	P- D7	0.630	10.9	1700
□	P-4B2	0.552	17.7	P- B2	0.466	14.6	1800
△	P-4F2	0.602	12.5	P- A5	0.476	16.2	1900
▲	P-4A2	0.606	15.3	P- A2	0.476	14.1	2000

NOTE:
A $\frac{3}{4}\phi$ MACHINE BOLT WAS USED WITH TWO O G WASHERS



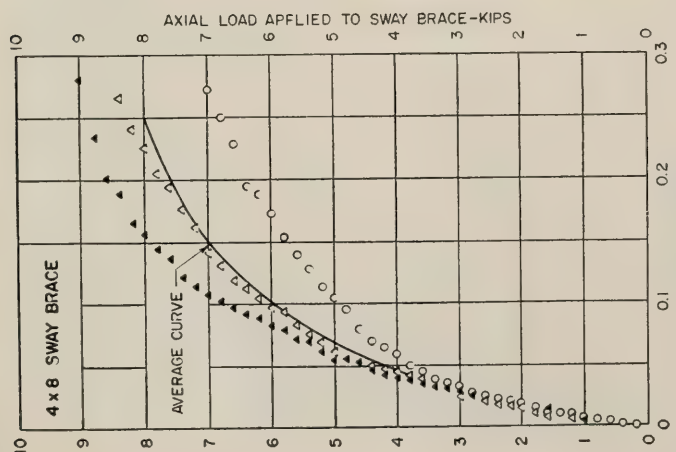
SYMBOLS	SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
	STATIC TESTS					
○	P-4A1	0.606		P- A1	0.476	
●	P-4A3	0.606		P- A3	0.476	
△	P-4B1	0.552		P- B1	0.466	

FIG. 22
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{3}{4}$ BOLTS
UNTREATED SOUTHERN PINE



SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS
●	P-4C2	0.574	18.0	P-C2	0.640	13.1	2700
○	P-4C4	0.574	16.5	P-C4	0.640	12.0	3250
□	P-4F1	0.602	14.0	P-F1	0.454	22.2	3500
■	P-4F3	0.602	16.5	P-F3	0.454	19.8	3700
△	P-4G2	0.536	11.3	P-B2	0.466	14.6	3800
▲	P-4B4	0.552	21.8	P-B4	0.466	15.0	3800

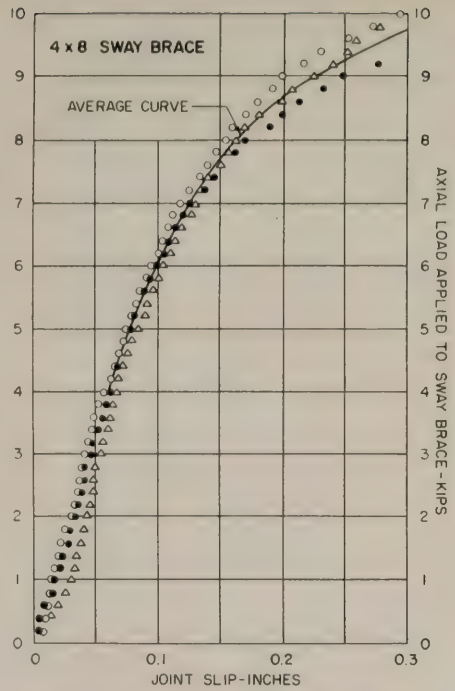
NOTE A $\frac{7}{8}\phi$ MACHINE BOLT WAS USED WITH TWO OG WASHERS

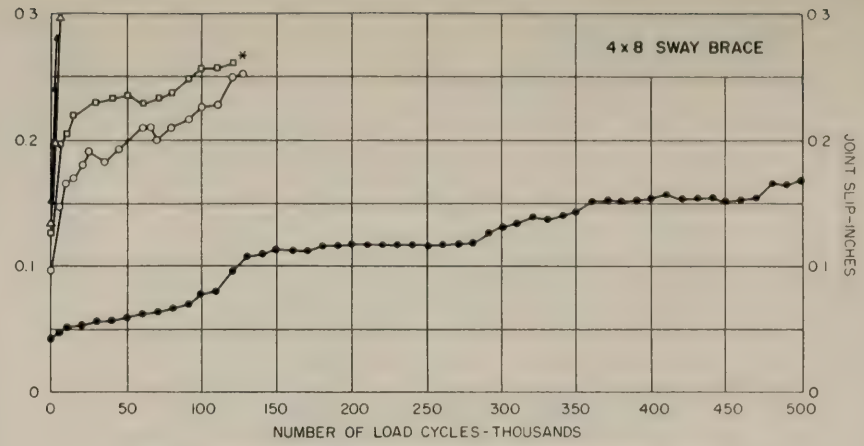


SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
○	P-4B3	0.552		P-B3	0.466	
△	P-4C1	0.574		P-C1	0.460	
▲	P-4C3	0.574		P-C3	0.640	

FIG. 23

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{7}{8}$ BOLTS
UNTREATED SOUTHERN PINE





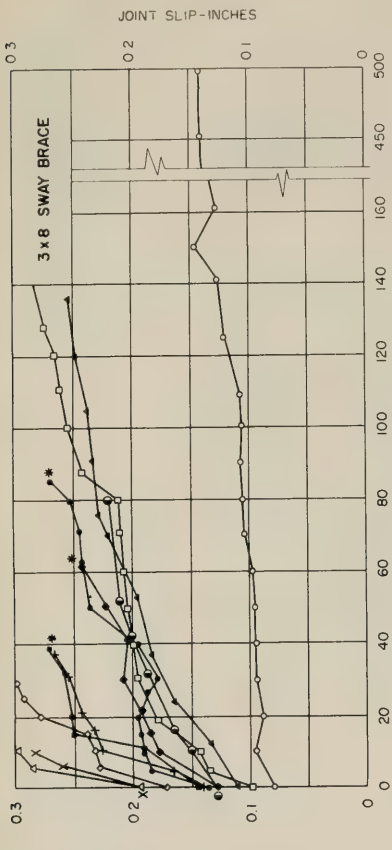
REPEATED LOAD TESTS							
SYMBOLS	SWAY			PILE			LOAD LBS.
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
●	P-4E4	0.577		P- C5	0.640		2800
○	P-4D2	0.556	15.9	P- D2	0.630	14.6	3900
⊡	P-4F4	0.602	13.0	P- F4	0.454	37.0	4400
△	P-4G1	0.536	10.8	P- B5	0.466	19.0	4600
▲	P-4D4	0.556	17.0	P- D4	0.630	21.0	5000

STATIC TESTS						
SYMBOLS	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	P-4D1	0.556		P- D1	0.630	
●	P-4D3	0.336		P- D3	0.630	
△	P-4E1	0.577		P- E1	0.560	

NOTE
A 1 ϕ MACHINE BOLT WAS USED WITH TWO O.G WASHERS
* A LARGE CHECK OPENED IN THE PILE

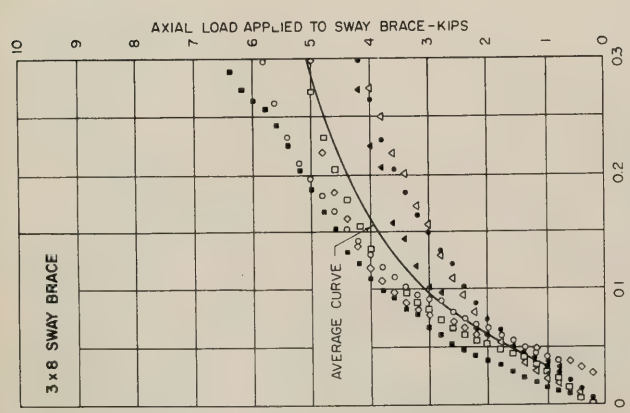
FIG 24

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1 BOLTS
UNTREATED SOUTHERN PINE



SYMBOLS	SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT	LOAD LBS
	REPEATED LOAD TESTS						
○	TP-3A2		11 7	TP-A2		16 7	1600
●	TP-3J3	0 560	18 0	TP-Y3	0 515	18 5	1800
□	TP-3K1	0 653	16 1	TP-Q1	0 543	17 1	1900
■	TP-3D1		17 7	TP-C1	0 513	17 6	2000
△	TP-3L3	0 514	22 8	TP-P3	0 580	20 9	2000
▲	TP-3C2		43 0	TP-E2	0 501	19 2	2000
◇	TP-3B2		23 5	TP-B2	0.455	24 3	2000
◆	TP-3K3	0 613	19 6	TP-Q3	0 543	19 1	2100
X	TP-3L1	0 575	15 5	TP-P1	0 497	19 4	2200
+	TP-3J1	0 431	16 0	TP-Y1	0 566	20 0	2300
◐	TP-3A1			TP-F1	0 646	14 7	2400

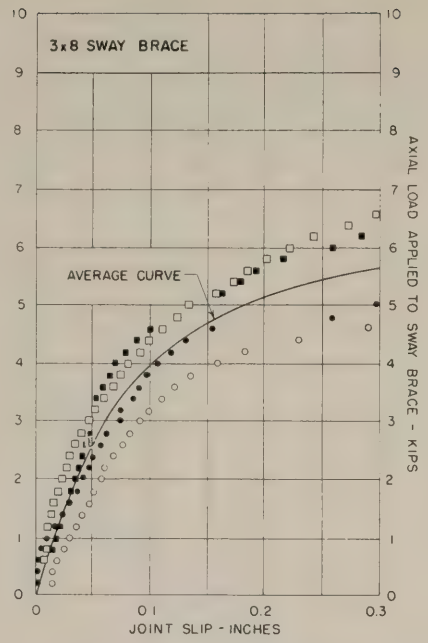
NOTE A $\frac{3}{4}$" MACHINE BOLT WAS USED WITH TWO O G WASHERS
* BOLT BROKE



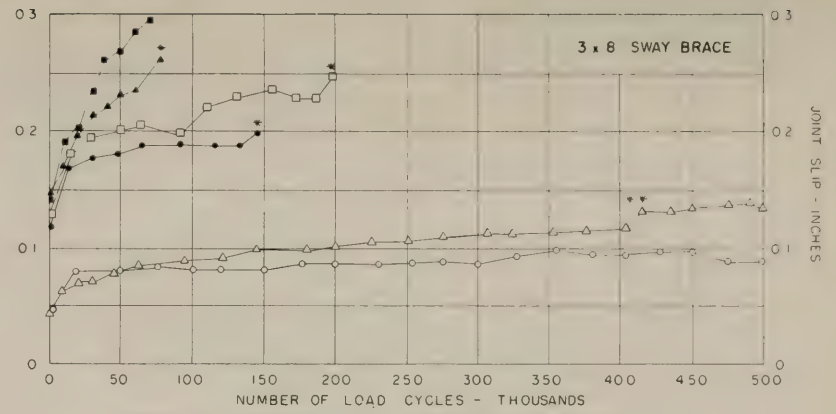
SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SWAY SPECIFIC GRAVITY	SWAY MOISTURE CONTENT	PILE SPECIMEN NUMBER	PILE SPECIFIC GRAVITY	PILE MOISTURE CONTENT
○	TP-3A3		18 3	TP-A3		17 4
●	TP-3B1		27 3	TP-B1	0 473	24 0
□	TP-3C1		20 8	TP-E1	0 744	17 4
■	TP-3A4		21 9	TP-F3	0 576	22 5
△	TP-3L2	0.528	23 1	TP-P2	0 498	24 5
▲	TP-3K2	0.654	22 5	TP-Q2	0.627	22 5
◇	TP-3J2	0.483	19 6	TP-Y2	0 530	19 8

FIG 25

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{3}{4}$" BOLTS
TREATED SOUTHERN PINE



STATIC TESTS						
SYMBOLS	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TP-3F1	0.533	24.2	TP-S1	0.529	19.0
●	TP-3G1	0.529	27.4	TP-T1	0.531	17.6
□	TP-3K4	0.623	20.8	TP-R2	0.452	19.6
■	TP-3M4	0.651	16.6	TP-R5	0.499	16.7



REPEATED LOAD TESTS							
SYMBOLS	SWAY			PILE			LOAD LBS
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
○	TP-3J4	0.521	15.2	TP-R1	0.483	14.0	1600
●	TP-3G4	0.593	21.7	TP-T4	0.527	18.0	1800
□	TP-3F2	0.590	21.1	TP-S2	0.436	16.0	2000
■	TP-3G3	0.558	13.5	TP-T3	0.491	18.5	2200
△	TP-3M1	0.557	12.1	TP-R3**	0.467	12.1	2400
▲	TP-3M3	0.626	21.7	TP-R4	0.475	14.0	3250

NOTE

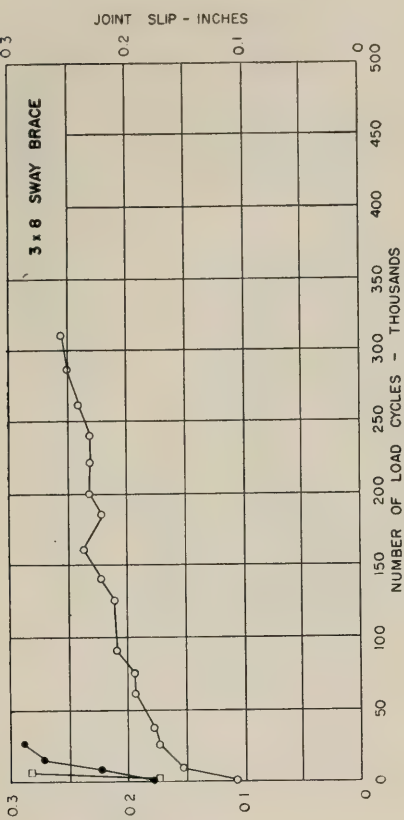
A $\frac{7}{8}\phi$ MACHINE BOLT WAS USED WITH TWO OG WASHERS

* BOLT BROKE

** PILE SPLIT UP MIDDLE

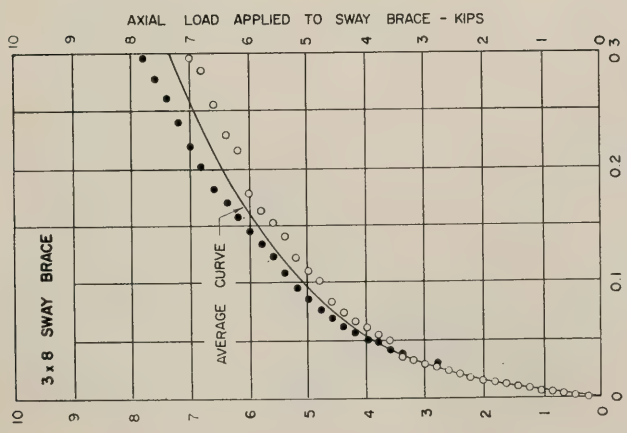
FIG 26

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS- $\frac{7}{8}$ BOLTS
TREATED SOUTHERN PINE



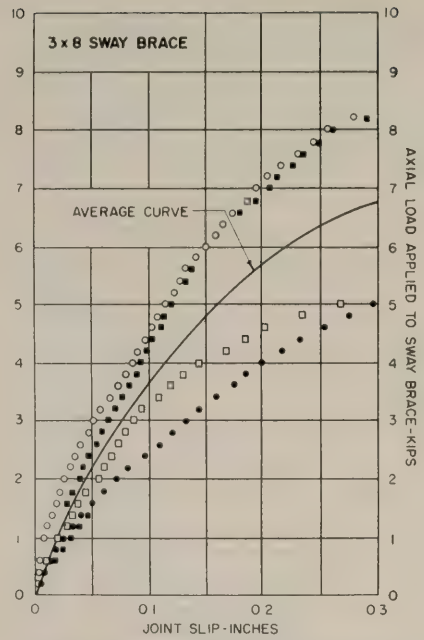
REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
○	TP-3N2	0.665	12.3	TP-02	0.513	15.2	3000
●	TP-3H3	0.556	18.1	TP-05	0.555	21.0	3250
□	TP-3H1	0.517	18.2	TP-03	0.488	19.1	3500

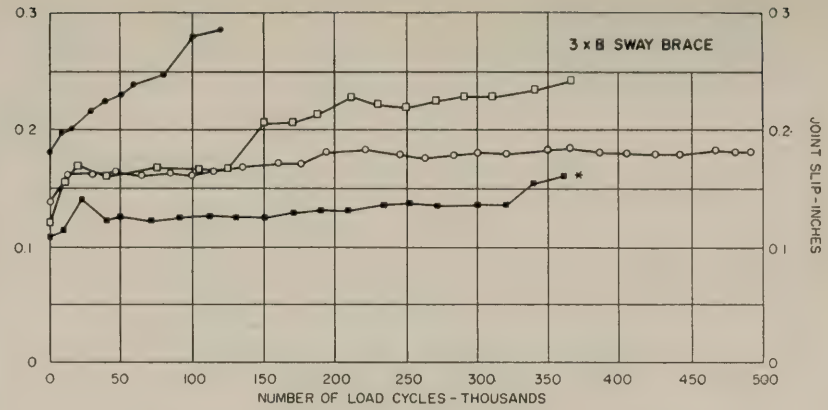
NOTE: A 1⅛ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS.
* BOLT BROKE.



STATIC TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
○	TP-3N1	0.592	19.5	TP-01	0.466	20.8	
●	TP-3H2	0.655	19.9	TP-04	0.519	22.9	

FIG. 27
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1 BOLTS
TREATED SOUTHERN PINE





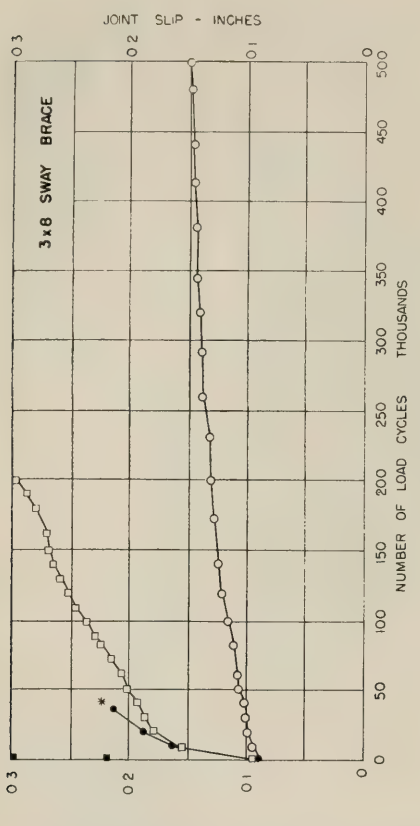
STATIC TESTS						
	SWAY			PILE		
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TP-30 2	0.523	16.6	TP-AA 6	0.473	12.7
●	TP-30 4	0.531	15.0	TP-TX 2	0.520	13.8
□	TP-3P 4	0.422	14.8	TP-AA 4	0.503	14.8
■	TP-3P 2	0.433	15 5	TP-AA 2	0.533	14 3

REPEATED LOAD TESTS							
	SWAY			PILE			
SYMBOLS	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS.
○	TP-3P3	0 418	13 3	TP-AA3	0.544	13 5	1800
●	TP-303	0.532	13.1	TP-TX1	0 445	9.7	2200
□	TP-3P5	0.424	11.9	TP-AA5	0.528	11.4	2500
■	TP-301	0.591	12 7	TP-AA7	0.430	8.8	3000
△	TP-3P1	0.452	14.2	TP-AA1**	0.562	12.7	3750

NOTE:
A $\frac{3}{4}\phi$ BOLT WAS USED WITH A $4\frac{1}{8}$ IN SINGLE CURVE SPIKE GRID. (HALF SEATED)
* BOLT BROKE
** HIGH LOAD RESULTED IN IMMEDIATE FAILURE OF THIS SPECIMEN

FIG 28

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
HALF SEATED $\frac{3}{4}$ BOLT, $4\frac{1}{8}$ GRID JOINT
TREATED SOUTHERN PINE



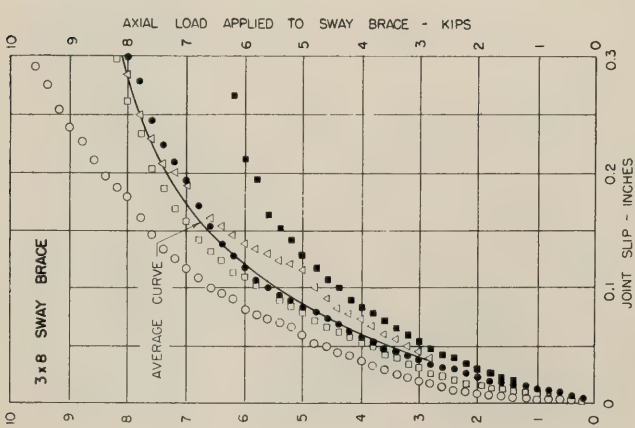
SYMBOLS	REPEATED LOAD TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	LOAD LBS
○	TP-3D4		17 5	TP - G2	0 455	15 7	3750
●	TP-3C3		17 4	TP - G3		17 3	3750
□	TP-3C4		19 2	TP - G1	0 673	15 0	4500
□	TP-3B4		37 0	TP - L2	0.569	18 2	5000

NOTE

A $\frac{3}{4}\phi$ BOLT WAS USED WITH A $4\frac{1}{8}$ IN SINGLE CURVE SPIKE GRID (FULLY SEATED)

* BOLT BROKE

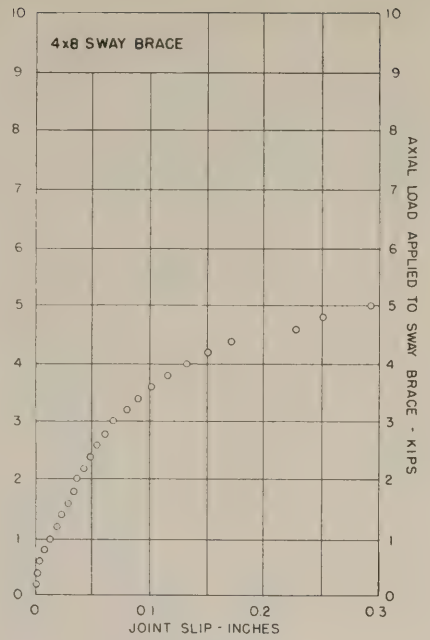
** GRID SEATED FIRST IN TEST MACHINE AT 14,000 - LB LOAD

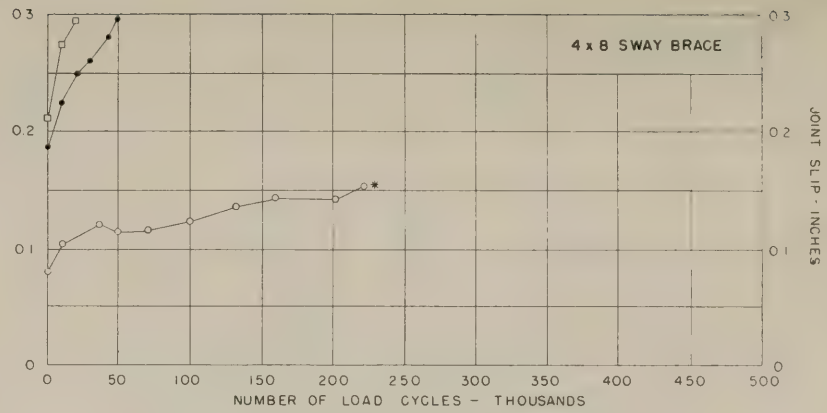


SYMBOLS	STATIC TESTS SWAY SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	PILE SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TP-3B3		26 3	TP - L1	0 627	18 0
●	TP-3E1		14 8	TP - A1		19 0
□	TP-3D3		20 6	TP - D2	0 464	26 1
⧈	TP-3D2		20 5	TP - C2	0 454	20 5
△	TP-3E2**		15 8	TP - M1	0.557	27 9

FIG 29

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
$\frac{3}{4}$ BOLT AND $4\frac{1}{8}$ GRID JOINTS
TREATED SOUTHERN PINE





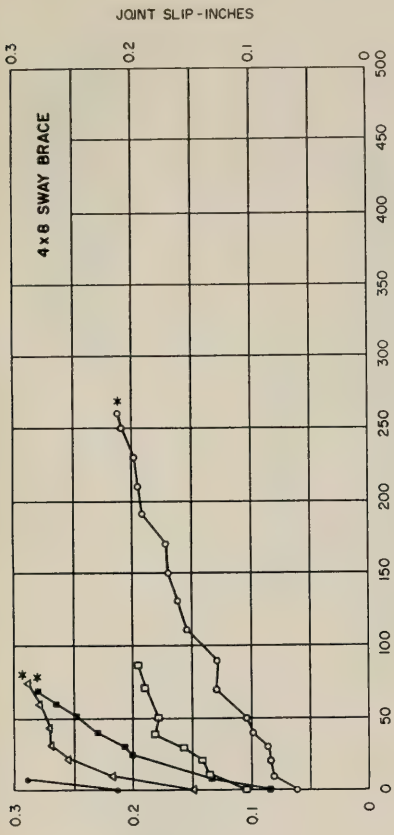
REPEATED LOAD TESTS							
SYMBOLS	SWAY			PILE			LOAD LBS.
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
○	TP-4E6	0.580	16.1	TP-BB9	0.540	17.9	2000
●	TP-4E5	0.554	24.7	TP-BB8	0.495	21.3	2500
□	TP-4E3	0.527	20.6	TP-BB6	0.521	24.9	3000

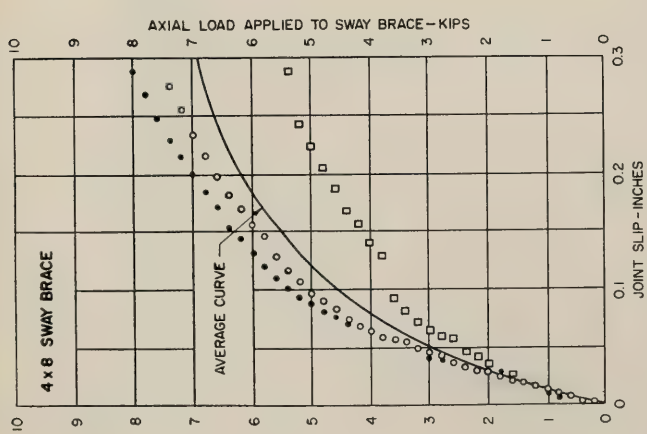
NOTE:
A $\frac{3}{4}$ ϕ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS
* BOLT BROKE

STATIC TESTS						
SYMBOLS	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TP-4E4	0.586	13.8	TP-BB7	0.528	9.9

FIG. 30

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - $\frac{3}{4}$ BOLTS
TREATED SOUTHERN PINE



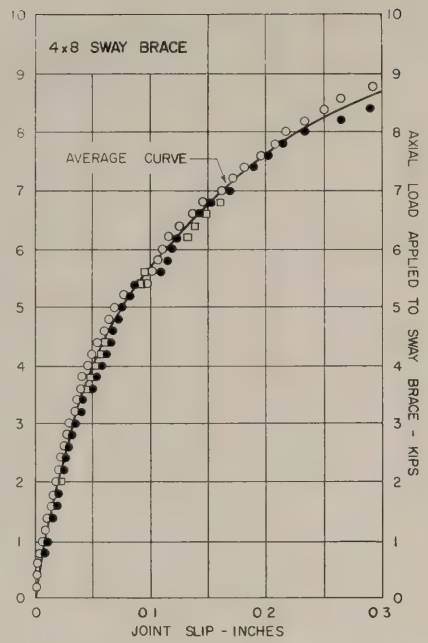


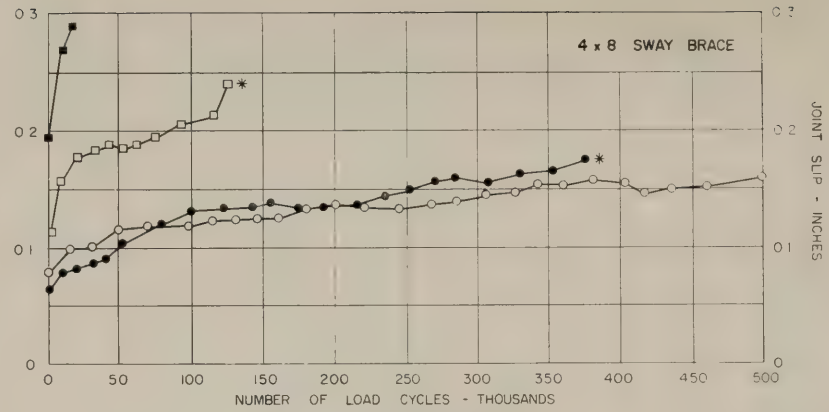
REPEATED LOAD TESTS							
SYMBOLS	SWAY			PILE			LOAD LBS.
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
○	TP-4D3	0.587	15.4	TP-BB3	0.471	11.4	2500
●	TP-4D1	0.538	17.7	TP-BB1	0.485	17.4	3000
□	TP-4B3	0.666	18.1	TP-W3	0.469	15.1	3000
■	TP-4B1	0.609	15.8	TP-W1	0.498	12.2	3250
△	TP-4C3	0.642	14.1	TP-U3			3500

NOTE:
A $\frac{7}{8}\phi$ MACHINE BOLT WAS USED WITH TWO O.G. WASHERS
* BOLT BROKE

STATIC TESTS						
SYMBOLS	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TP-4C4	0.659	14.9	TP-U4	0.535	16.1
●	TP-4B2	0.631	15.2	TP-W2	0.510	16.4
□	TP-4D2	0.567	19.1	TP-BB2	0.505	19.8

FIG 31
STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS- $\frac{7}{8}$ BOLTS
TREATED SOUTHERN PINE





STATIC TESTS						
SYMBOLS	SWAY			PILE		
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT
○	TP-4C2	0.637	17.7	TP-U2	0.539	12.8
●	TP-4A2	0.737	17.4	TP-V2	0.653	13.3
□	TP-4E2	0.584	21.4	TP-BB5	0.499	21.4

REPEATED LOAD TESTS							
SYMBOLS	SWAY			PILE			LOAD LBS
	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	SPECIMEN NUMBER	SPECIFIC GRAVITY	MOISTURE CONTENT	
○	TP-4C1	0.632	17.7	TP-U1	0.506	10.5	3500
●	TP-4A1	0.696	13.0	TP-V1	0.694	10.9	3800
□	TP-4A3	0.601	13.0	TP-V3	0.675	11.4	4000
■	TP-4E1	0.593	13.5	TP-BB4	0.530	16.6	4200

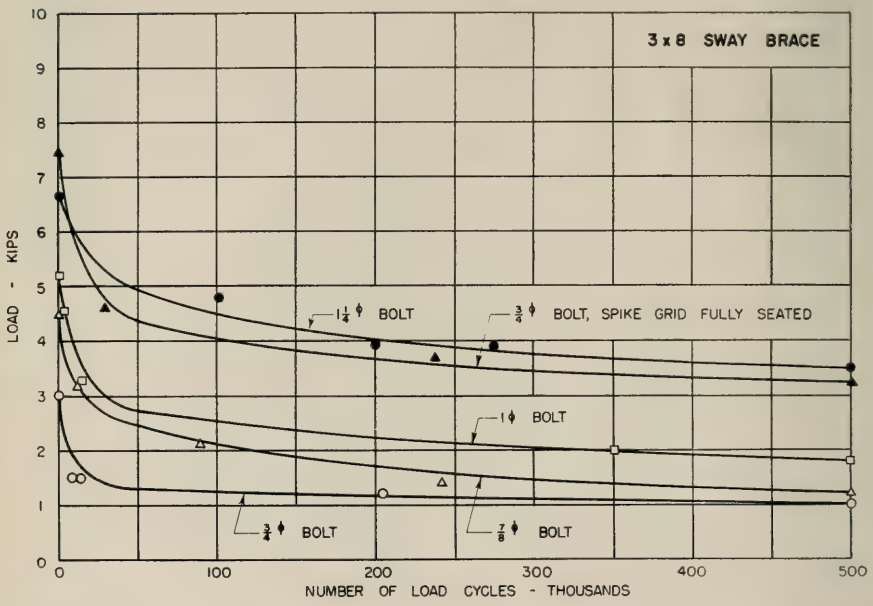
NOTE.
A 1ϕ MACHINE BOLT WAS USED WITH TWO OG WASHERS
✱ BOLT BROKE.

FIG 32

STATIC & REPEATED LOAD CURVES
BOLTED TIMBER JOINT STUDIES
BOLTED JOINTS - 1 BOLTS
TREATED SOUTHERN PINE

FIG 33

LOAD CYCLE CURVES FOR $\frac{1}{4}$-INCH SLIP
BOLTED TIMBER JOINT STUDIES
UNTREATED DOUGLAS FIR



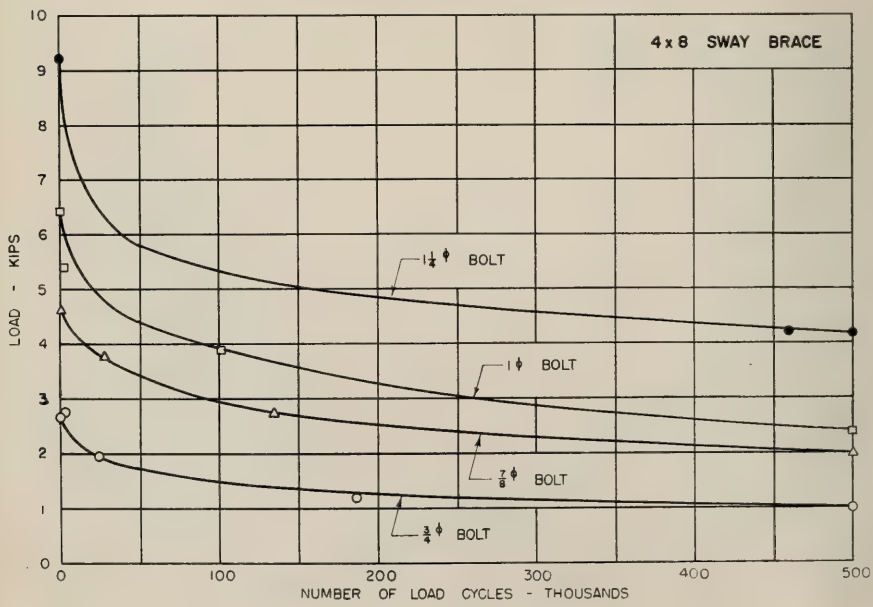
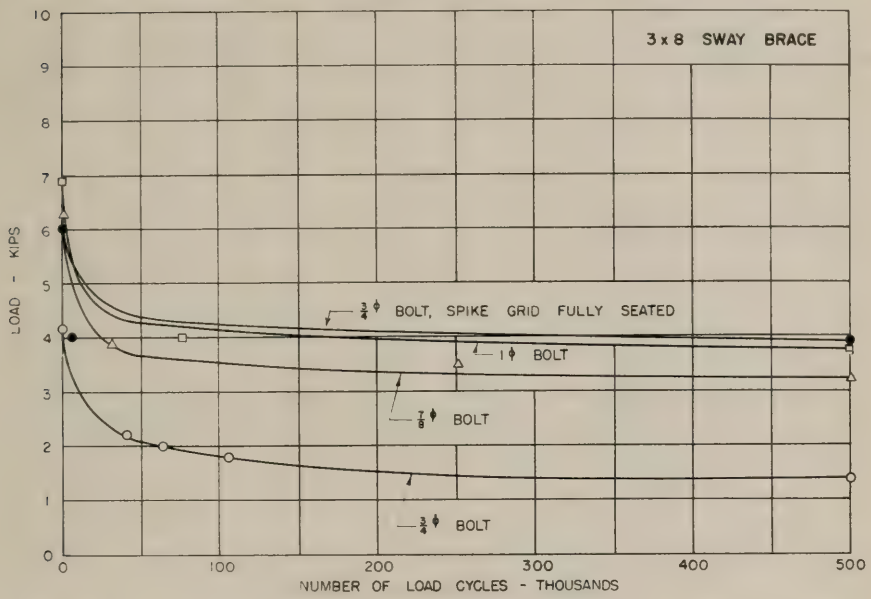


FIG 34

LOAD CYCLE CURVES FOR $\frac{1}{4}$-INCH SLIP
BOLTED TIMBER JOINT STUDIES
TREATED DOUGLAS FIR



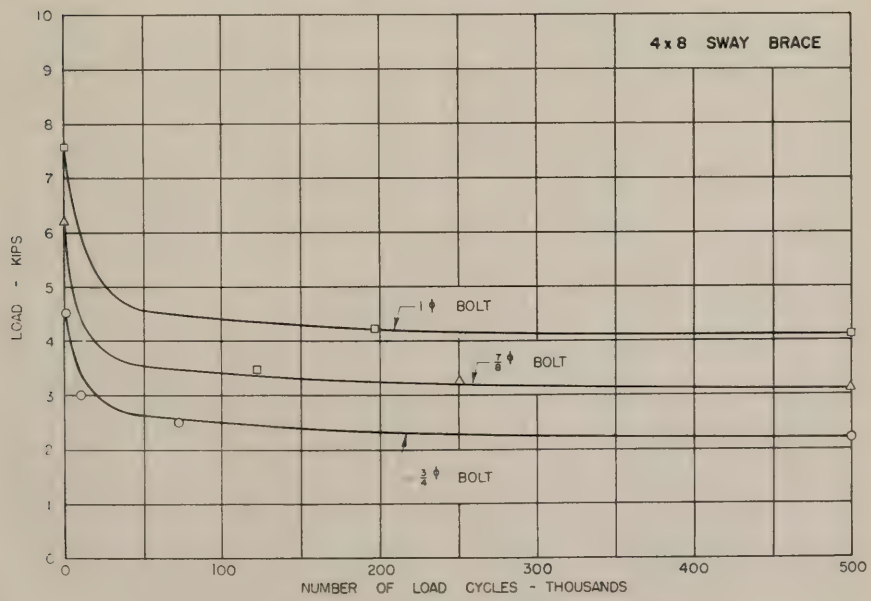
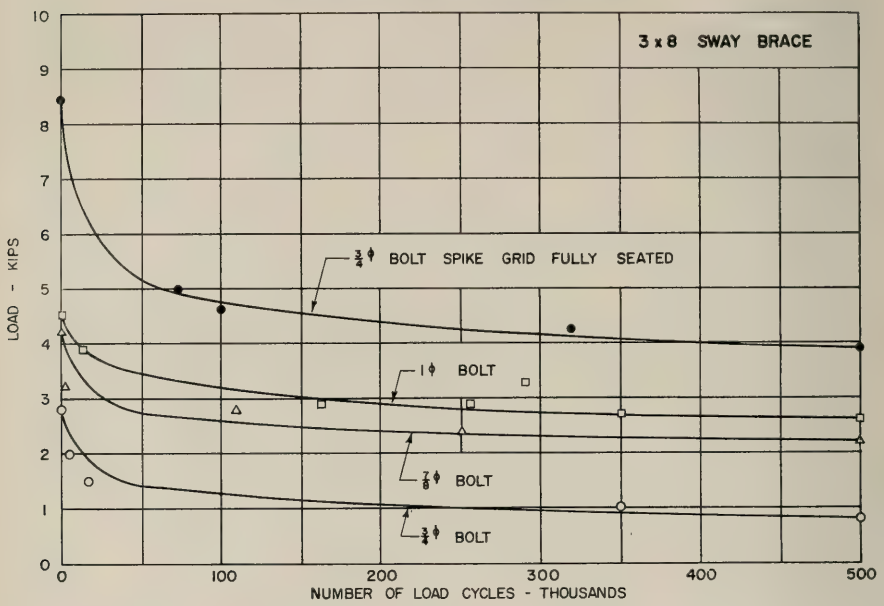


FIG. 35

LOAD CYCLE CURVES FOR $\frac{1}{4}$-INCH SLIP BOLTED TIMBER JOINT STUDIES UNTREATED SOUTHERN PINE



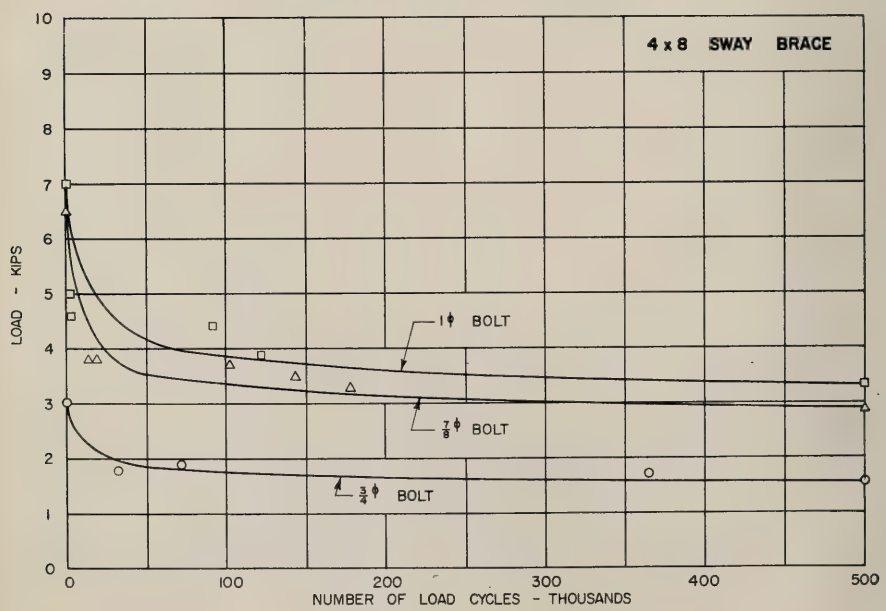
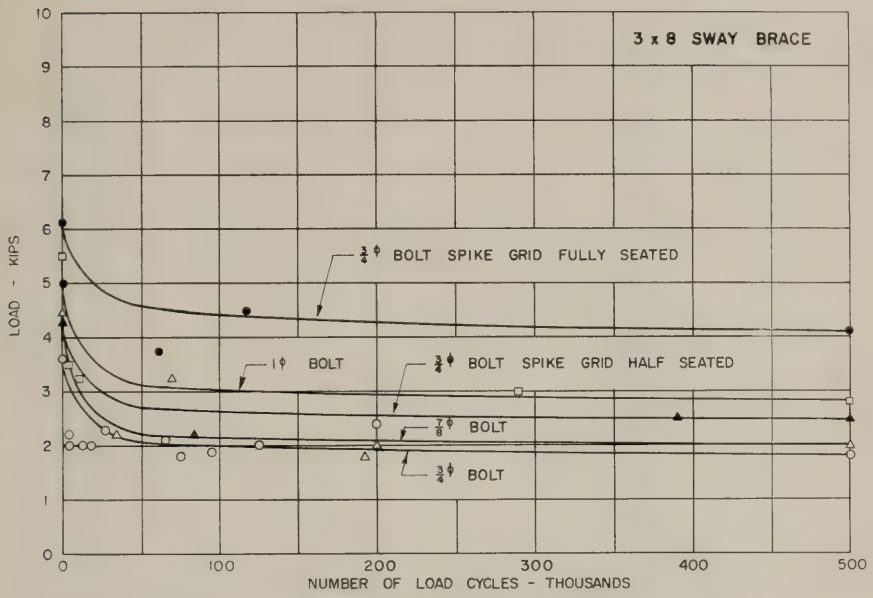
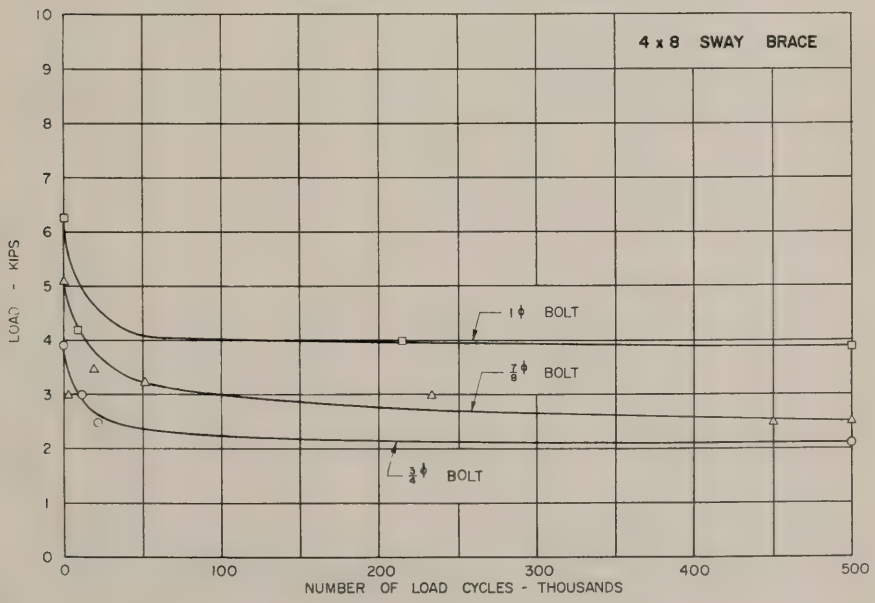


FIG. 36

LOAD CYCLE CURVES FOR $\frac{1}{4}$-INCH SLIP BOLTED TIMBER JOINT STUDIES TREATED SOUTHERN PINE





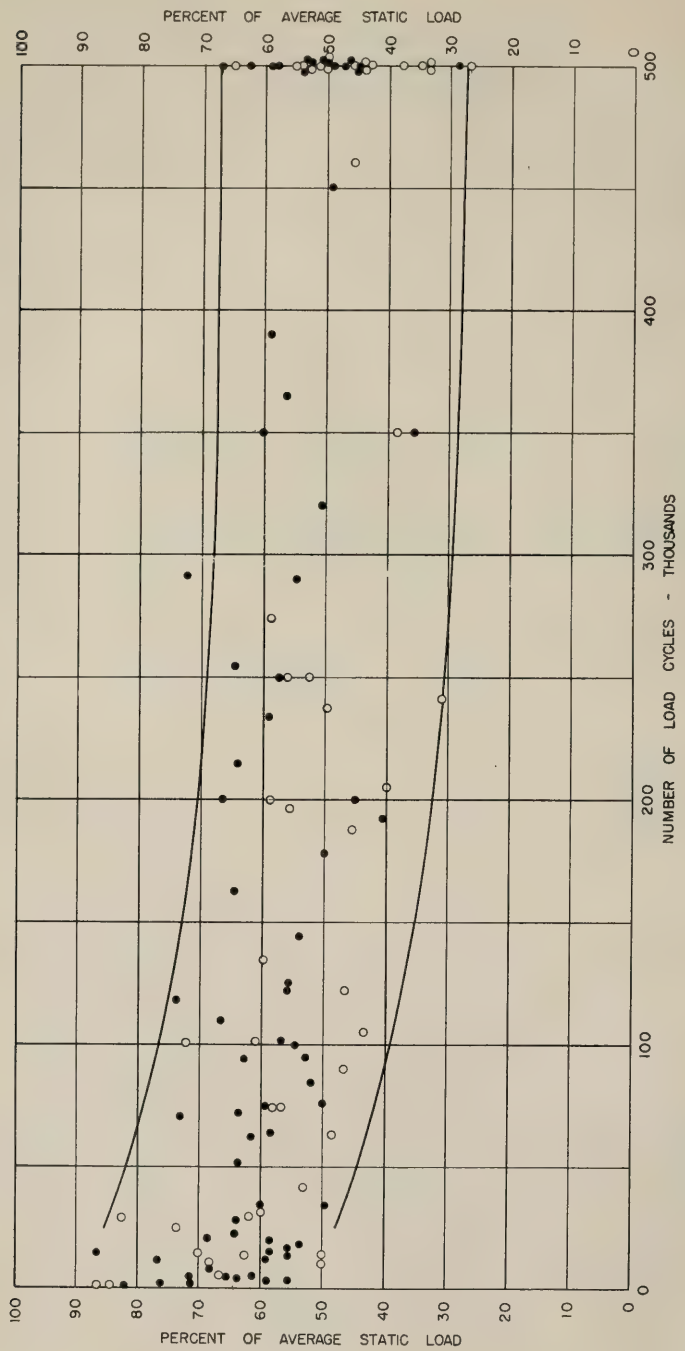


FIG. 37
REPEATED LOAD TESTS
ON TIMBER JOINTS
BOLTED TIMBER JOINT STUDIES

Advance Report of Committee 3—Ties

Report on Assignment 4

Tie Renewals and Cost per Mile of Maintained Track

L. W. Kistler (chairman, subcommittee), E. L. Collette, R. W. Cook, W. L. Kahler, C. M. Long, J. W. Neikirk, H. B. Orr, C. A. Peebles, W. C. Reichow, R. B. Smith.

The annual statistics compiled by the Bureau of Railway Economics, AAR, providing information on cross tie renewals and cost data for 1958, are presented herewith in Tables A and B.

Last year's report states that the total of 21,525,233 new wooden cross ties inserted in 1957 was the lowest in more than 50 years and that the reduced traffic (earnings) in 1957 undoubtedly was a dominant factor in the reduction mentioned.

The 1958 statistics show 580,000 fewer equated gross ton miles per mile of track than in 1957, which is equivalent to a reduction of 8.82 percent. Thus in 1958 the lighter traffic density was even more dominantly a factor in reducing cross tie renewals. But while reduced renewals were expected, it is doubtful if very many maintenance men anticipated that only 15,231,689 new wooden cross ties would be laid in tracks of the Class I Railroads of the United States last year. This is an all-time low, amounting to only 47 ties per mile of maintained track.

In addition, 797,869 second-hand ties were reported used, which is 5.2 percent of the quantity of new ties reported. The installation of these second-hand ties materially reduced the number of new ties inserted by eight of the reporting railroads, but since a number of railroads do not report their usage of such ties, the figures do not enter into the calculation of the number of ties renewed per mile, and similar data.

There were 6,293,544 fewer new ties applied in 1958 than in 1957, an almost unbelievable reduction, amounting to slightly over 29 percent. Reduced insertions occurred in all regions except the New England, where 8464 more cross ties were installed. The most drastic cuts in renewals were in the Pocahontas and Great Lakes Regions, with reductions of 54.6 and 53.0 percent, respectively.

Since reduced traffic (earnings) largely dictated cross tie renewals, analysis of the 1958 data is almost meaningless from a life-expectancy or tie service-life standpoint. Therefore, the following comparisons of 1958 with 1957 are interesting, but not conducive to factual conclusions.

Average cost of new cross ties	Increased $0.07 per tie
Renewals per mile—1958	Decreased 20 ties
Renewals per mile—5-year average	Decreased 8.4 ties to 65.8
Renewal cost per mile of maintained track	Decreased $68.00
Renewal cost per 1000 equated gross ton miles	Decreased $0.77

However, the following data for all Class I Railroads of the United States clearly indicate a downward trend in insertions.

	New Ties Inserted	**Estimated Service Life*
1958 renewals per mile	47.0	64.00 years
5-year average renewals per mile	65.8	45.71 "
10-year average renewals per mile	77.9	38.61 "
20-year average renewals per mile	103.6	29.03 "

* Based on 3008 cross ties per mile.

Your subcommittee chairman recently saw a number of cross ties that had been removed from main-line tracks by one of the larger railroads. These were mostly treated yellow pine, bearing 1927 and 1928 dating nails. After over 30 years in track, most of them were sound and had been removed primarily because of physical or mechanical deterioration. Perhaps with our modern methods of treatment and higher standards of maintenance, it is realistic to contemplate 40 years or more average service life and plan our future requirements accordingly.

Table A

CROSS TIE STATISTICS (EXCLUDING SWITCH & BRIDGE) FOR CLASS I RAILROADS IN THE UNITED STATES AND LARGE CANADIAN RAILROADS

Calendar year ended December 31, 1958

Road	Cross ties laid in replacement: New wooden ties untreated (U): Number	New wooden ties untreated (U): Average cost	New wooden ties treated (T): Number	New wooden ties treated (T): Average cost	Total all new wooden ties laid: Number	Total all new wooden ties laid: Average cost	Ties other than wood(S) & second-hand (*) reapplied ties	Total ties applied	Miles of maintained tracks (item 25)	Estimated total cross ties in all maintained tracks (item 24)	Average number of cross ties per mile of maintained track	Number of equated gross ton-miles a (thousands)	Number of equated gross ton-miles per mile of maintained track (thous.)	New wooden cross tie replacement averages: Per cent renewal to all ties in maintained track	Number laid per mile of maintained track	Renewal cost per mile of maintained track	Renewal cost per 1000 equated gross ton-miles (cents)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
NEW ENGLAND REGION:																	
Bangor & Aroostook	74 825	$2.11	44 609	$4.66	119 434	3.06	-	119 434	806.25	2 325 427	2 884	1 796 348	2 228	5.14	148	$454	20.36
Boston & Maine	-	-	48 850	3.86	48 850	3.86	-	48 850	2 499.09	7 390 032	2 957	10 192 267	4 078	0.66	20	76	1.85
Canadian Pacific (lines in Me.	-	-	17 528	3.69	17 528	3.69	-	17 528	214.50	626 212	2 919	1 538 126	7 171	2.80	82	302	4.21
Central Vermont	-	-	35 182	5.12	35 182	5.12	* 6 521	41 703	433.98	1 285 732	2 963	1 758 701	4 052	2.74	81	415	10.23
Maine Central	16 094	2.33	64 087	4.07	80 181	3.72	* 1 121	81 302	1 108.58	3 316 509	2 992	3 320 908	2 996	2.42	72	269	8.99
New York Connecting	-	-	3 619	4.93	3 619	4.93	-	3 619	26.30	82 375	3 132	285 760	10 865	4.39	138	679	6.25
New York, New Haven & Hartford	-	-	96 297	3.87	96 297	3.87	-	96 297	3 396.26	9 193 883	2 707	18 067 000	5 320	1.05	28	110	2.06
Rutland	-	-	15 378	3.95	15 378	3.95	-	15 378	387.11	1 211 200	3 129	651 310	1 682	1.27	40	157	9.33
Total	90 919	2.15	325 550	4.16	416 469	3.72	* 7 642	424 111	8 872.07	25 431 370	2 866	37 610 420	4 239	1.64	47	175	4.12
GREAT LAKES REGION:																	
Ann Arbor	-	-	15 663	4.34	15 663	4.34	-	15 663	399.54	1 212 595	3 035	1 348 193	3 374	1.29	39	170	5.04
Delaware & Hudson	-	-	40 653	1.87	40 653	1.87	-	40 653	1 241.80	3 769 348	3 035	8 431 336	6 790	1.08	33	61	0.90
Delaware, Lackawanna & Western	-	-	128 626	4.72	128 626	4.72	-	128 626	1 935.01	6 189 108	3 198	13 240 504	6 843	2.08	66	314	4.59
Detroit & Toledo Shore Line	-	-	5 672	5.15	5 672	5.15	* 236	5 908	154.01	446 871	2 902	618 525	4 016	1.27	37	190	4.72
Erie	-	-	83 317	4.00	83 317	4.00	-	83 317	4 363.40	12 810 083	2 936	29 857 570	6 843	0.65	19	76	1.11
Grand Trunk Western	-	-	80 061	3.87	80 061	3.87	-	80 061	1 815.04	5 742 736	3 164	8 455 502	4 659	1.39	44	171	3.66
Lehigh & Hudson River	-	-	6 732	5.08	6 732	5.08	* 533	7 265	101.72	275 000	2 703	732 851	7 205	2.45	66	336	4.67
Lehigh & New England	-	-	11 035	4.37	11 035	4.37	-	11 035	229.16	693 845	3 028	695 840	3 036	1.59	48	210	6.93
Lehigh Valley	-	-	61 766	3.23	61 766	3.23	-	61 766	2 287.74	6 925 505	3 027	9 813 314	4 290	0.89	27	87	2.03
Monongahela	-	-	6 787	4.35	6 787	4.35	-	6 787	244.73	716 528	2 928	632 550	2 585	0.95	28	121	4.67
New York Central	17	1.65	414 954	3.05	414 971	3.05	*116 386	531 357	18 764.53	58 254 620	3 105	118 869 934	6 335	0.71	22	67	1.07
New York, Chicago & St. Louis	-	-	54 000	4.05	54 000	4.05	-	54 000	3 453.96	10 751 138	3 113	26 971 000	7 809	0.50	16	63	0.81
New York, Susquehanna & Western	-	-	1 988	4.45	1 988	4.45	* 3 324	5 312	189.13	551 043	2 914	263 893	1 395	0.36	11	47	3.35
Pittsburgh & Lake Erie	-	-	48 250	1.80	48 250	1.80	-	48 250	676.55	2 064 648	3 052	2 642 280	3 906	2.34	71	129	3.29
Pittsburgh & West Virginia	-	-	11 021	5.49	11 021	5.49	* 824	11 845	184.15	562 512	3 055	1 035 071	5 621	1.96	60	329	5.85
Wabash	-	-	123 831	4.58	123 831	4.58	-	123 831	3 102.20	9 715 141	3 132	22 514 224	7 258	1.27	40	183	2.52
Total	17	1.65	1 094 356	3.60	1 094 373	3.60	*121 303	1 215 676	39 142.67	120 680 721	3 083	246 122 587	6 288	0.91	28	101	1.60
CENTRAL EASTERN REGION:																	
Akron, Canton & Youngstown	-	-	559	4.51	559	4.51	* 741	1 300	220.83	651 587	2 951	633 262	2 868	0.09	3	11	0.40
Baltimore & Ohio	-	-	480 735	3.55	480 735	3.55	-	480 735	9 909.74	28 458 827	2 872	71 691 229	7 234	1.69	49	172	2.38
Bessemer & Lake Erie	-	-	32 606	4.52	32 606	4.52	-	32 606	408.36	1 368 012	3 350	2 319 059	5 679	2.38	80	361	6.35
Central R.R. of New Jersey	-	-	20 940	3.22	20 940	3.22	-	20 940	1 213.26	3 395 187	2 798	6 215 881	5 123	0.62	17	56	1.09
Chicago & Eastern Illinois	-	-	71 064	3.84	71 064	3.84	-	71 064	1 301.21	3 959 972	3 043	6 596 804	5 070	1.79	55	210	4.13
Chicago & Illinois Midland	-	-	6 119	3.59	6 119	3.59	-	6 119	162.11	486 330	3 000	672 517	4 149	1.26	38	135	3.26
Detroit, Toledo & Ironton	-	-	15 178	3.82	15 178	3.82	* 10 819	25 997	596.84	1 718 899	2 880	2 017 350	3 380	0.88	25	97	2.87
Elgin, Joliet & Eastern	-	-	9 980	4.08	9 980	4.08	* 17 403	27 383	843.07	2 588 879	3 071	2 178 478	2 584	0.39	12	48	1.87
Illinois Terminal	-	-	14 717	3.31	14 717	3.31	* 10 240	24 957	484.72	1 512 862	3 121	1 012 790	2 089	0.97	30	101	4.81
Long Island	-	-	37 815	4.57	37 815	4.57	-	37 815	711.94	1 955 656	2 747	3 658 438	5 139	1.93	53	243	4.72
Missouri-Illinois	-	-	4 066	2.79	4 066	2.79	-	4 066	216.29	679 345	3 141	402 538	1 861	0.60	19	52	2.81
Monon	-	-	36 942	3.31	36 942	3.31	-	36 942	721.60	2 241 163	3 106	3 025 060	4 192	1.65	51	169	4.04
Pennsylvania	-	-	802 719	4.37	802 719	4.37	-	802 719	20 049.72	57 482 975	2 867	151 799 730	7 571	1.40	40	175	2.31
Pennsylvania-Reading Seashore Lines	-	-	25 259	4.92	25 259	4.92	-	25 259	503.87	1 369 973	2 719	816 162	1 620	1.84	50	246	15.22
Reading Company	-	-	46 148	4.18	46 148	4.18	-	46 148	2 719.58	7 528 669	2 768	14 252 219	5 241	0.61	17	71	1.35
Staten Island Rapid Transit	-	-	664	6.02	664	6.02	-	664	88.21	225 818	2 560	129 373	1 467	0.29	8	45	3.09
Western Maryland	-	-	50 601	4.41	50 601	4.41	-	50 601	1 121.75	3 264 058	2 910	7 213 787	6 431	1.55	45	199	3.09
Total	-	-	1 656 112	4.06	1 656 112	4.06	* 39 203	1 695 315	41 273.10	118 888 212	2 881	274 634 677	6 654	1.39	40	163	2.45
POCAHONTAS REGION:																	
Chesapeake & Ohio	-	-	111 190	3.67	111 190	3.67	-	111 190	8 267.49	24 844 594	3 005	71 920 501	8 699	0.45	13	49	0.57
Norfolk & Western	-	-	230 059	3.97	230 059	3.97	* 11 674	241 733	4 377.18	13 569 258	3 100	45 050 624	10 292	1.70	53	209	2.03
Richmond, Fredericksburg & Potomac	-	-	13 558	4.28	13 558	4.28	* 3 146	16 704	410.32	1 253 000	3 054	4 266 875	10 399	1.08	33	142	1.36
Virginian	-	-	61 269	4.05	61 269	4.05	-	61 269	967.30	2 969 932	3 070	9 401 470	9 719	2.06	63	256	2.64
Total	-	-	416 076	3.91	416 076	3.91	* 14 820	430 896	14 022.29	42 636 784	3 041	130 639 470	9 317	0.98	30	116	1.25
SOUTHERN REGION:																	
Alabama Great Southern	-	-	30 407	4.52	30 407	4.52	-	30 407	561.81	1 693 148	3 014	3 866 987	6 883	1.80	54	245	3.55
Alabama, Tennessee & Northern	-	-	8 971	3.08	8 971	3.08	-	8 971	232.93	737 822	3 168	765 668	3 287	1.22	39	119	3.61
Atlanta & St. Andrews Bay	-	-	8 874	4.51	8 874	4.51	-	8 874	118.36	359 769	3 040	547 518	4 626	2.47	75	339	7.32
Atlanta & West Point	-	-	15 315	4.13	15 315	4.13	-	15 315	145.96	395 329	2 708	668 016	4 577	3.87	105	434	9.48
Atlantic Coast Line	-	-	540 956	3.83	540 956	3.83	-	540 956	7 099.81	22 151 407	3 120	36 038 513	5 076	2.44	76	292	5.75
Carolina & Northwestern	-	-	11 852	4.15	11 852	4.15	* 2 324	14 176	302.80	895 175	2 956	162 382	536	1.32	39	103	30.33
Central of Georgia	-	-	223 646	3.44	223 646	3.44	-	223 646	2 264.15	6 535 129	2 886	9 299 967	4 107	3.42	99	339	8.26
Charleston & Western Carolina	-	-	69 268	4.29	69 268	4.29	* 182	69 450	432.88	1 273 415	2 942	1 289 676	2 979	5.44	160	687	23.06
Cincinnati, New Orleans & Tex. Pac.	-	-	56 894	4.29	56 894	4.29	-	56 894	717.84	2 121 486	2 955	6 244 082	11 485	2.68	79	340	2.96
Clinchfield	-	-	42 518	4.22	42 518	4.22	-	42 518	427.19	1 369 056	3 205	4 656 993	10 901	3.11	100	420	3.85
Florida East Coast	7 584	2.56	164 877	4.11	172 461	4.04	* 1 456	173 917	1 175.24	3 410 792	2 902	6 341 632	5 396	5.06	147	593	11.00
Georgia	-	-	59 640	3.78	59 640	3.78	-	59 640	438.26	1 329 535	3 034	1 595 162	3 640	4.49	136	514	14.12
Georgia & Florida	54 977	1.77	3 195	4.95	58 172	2.05	-	58 172	368.61	995 247	2 700	579 758	1 573	5.84	158	323	20.53
Georgia Southern & Florida	-	-	27 242	4.40	27 242	4.40	-	27 242	476.54	1 497 082	3 142	2 432 234	5 104	1.82	57	252	4.93
Gulf, Mobile & Ohio	5 838	1.40	272 872	3.39	278 710	3.35	-	278 710	3 494.99	11 072 129	3 168	16 334 561	4 674	2.52	80	267	5.71
Illinois Central	-	-	455 830	3.85	455 830	3.85	* 71	455 901	9 728.68	29 696 947	3 053	54 438 735	5 596	1.53	47	181	3.23
Louisville & Nashville	-	-	562 227	3.51	562 227	3.51	-	562 227	8 202.60	23 160 942	2 824	47 743 101	5 820	2.43	69	241	4.14
New Orleans & Northeastern	-	-	19 940	5.12	19 940	5.12	-	19 940	300.55	888 232	2 955	2 494 230	8 299	2.24	66	340	4.10
Norfolk Southern	-	-	82 678	3.15	82 678	3.15	-	82 678	711.61	2 076 223	2 918	1 511 112	2 124	3.98	116	365	17.21
Piedmont & Northern	-	-	19 550	4.69	19 550	4.69	-	19 550	186.00	573 338	3 082	336 375	1 808	3.41	105	493	27.27
Savannah & Atlanta	-	-	32 275	3.02	32 275	3.02	-	32 275	192.82	596 914	3 096	497 141	2 578	5.41	167	506	19.61
Seaboard Air Line	-	-	348 882	3.90	348 882	3.90	-	348 682	5 664.78	17 078 821	3 015	34 600 363	6 108	2.04	62	240	3.94
Southern Ry.	-	-	418 843	4.68	418 843	4.68	-	418 843	8 330.01	25 822 203	3 100	47 889 368	5 749	1.62	50	235	4.09
Tennessee Central	60	1.75	14 392	2.88	14 452	2.88	-	14 452	347.34	1 051 746	3 028	538 205	1 550	1.37	42	120	7.73
Western Ry. of Alabama	-	-	23 801	4.14	23 801	4.14	-	23 801	180.81	540 538	2 990	773 219	4 276	4.40	132	545	12.75
Total	[illegible]	[illegible]	3 514 945	3.86	3 583 [illegible]	3.83	* 4 033	3 587 437	52 102.57	157 322 435	3 019	283 645 003	5 444	2.28	69	263	4.84

TABLE A

[illegible] CROSS TIES (EXCLUDING SWITCH AND BRIDGE TIES) FOR CLASS I [illegible] [illegible]

Calendar year ended December 31, 1958

Name	Cross ties laid in replacement: New wooden ties untreated (U) Number	Average cost	New wooden ties treated (T) Number	Average cost	Total all new wooden ties laid Number	Average cost	Ties other than wood (o), second-hand (*) reapplied ties	Total ties applied	Miles of maintained tracks (item 25)	Estimated total cross ties in all maintained tracks (item 24)	Average number of cross ties per mile of maintained track	Number of equated gross ton-miles a (thousands)	Number of equated gross ton-miles per mile of maintained track (thous.)	Per cent renewal to all ties in maintained track	Number laid per mile of maintained track	Renewal cost per mile of maintained track	Renewal cost per 1,000 equated gross ton-miles
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Northwestern Region:																	(cents)
Chicago & North Western	-	-	646 775	$3.88	646 775	$3.88	* 1[illegible]9 036	805 811	12 577.90	37 412 204	2 974	40 71[illegible] 526	3 237	1.73	51	$199	[illegible]
Chicago Great Western		-	170 294	3.64	170 294	3.64	-	17[illegible] 294	1 803.41	5 467 435	2 [illegible]	7 [illegible]15 084	4 3[illegible]4	3.15	34	[illegible]	7.[illegible]
Chicago, Milwaukee, St. Paul & Pac.	-	-	30[illegible] 646	3.84	309 646	3.84	* 188 [illegible]	49[illegible] 331	13 145.11	40 112 259	3 051	50 431 030	3 836	0.77	24	90	2.36
Duluth, Missabe & Iron Range	87	$1.71	49 560	3.4[illegible]	49 647	3.42	-	49 647	1 036.62	[illegible]	2 979	4 [illegible]81 [illegible]53	3 937	1.61	48	164	4.16
Duluth, South Shore & Atlantic	-	-	51 146	3.70	51 146	3.70	-	51 146	562.64	1 [illegible]7 159	[illegible]3	1 173 6[illegible]	2 0[illegible]	3.[illegible]7	[illegible]1	3[illegible]	1[illegible].11
Duluth, Winnipeg & Pacific	243	2.35	[illegible]	2.[illegible]1	[illegible] 612	2.84	-	6 612	21[illegible].28	601 113	2 859	1 007 033	4 789	1.13	3[illegible]	[illegible]	1.92
Great Northern	5[illegible]	[illegible].14	621 811	4.37	621 891	4.37	* 11 2[illegible]	740 093	10 238.2[illegible]	32 159 349	3 141	51 346 119	5 015	1.93	61	[illegible]	[illegible]
Green Bay & Western	[illegible]3	1.51	5 [illegible]	3.40	5 415	3.30	-	5 415	267.81	776 7[illegible]5	2 900	621 035	2 319	0.70	2[illegible]	67	2.88
Lake Superior & Ishpeming	187	1.96	1[illegible] 194	3.[illegible]3	16 386	2.[illegible]4	-	16 386	295.87	752 130	2 542	173 436	586	2.18	55	163	27.7[illegible]
Minneapolis & St. Louis	[illegible]	1.00	111 870	3.69	1[illegible] 137	3.50	-	120 137	1 51[illegible]	4 54[illegible] [illegible]1	2 9[illegible]4	3 86[illegible] [illegible]	2 543	[illegible].[illegible]4	7[illegible]	[illegible]77	1[illegible]
Minneapolis, Northfield & Southern	-	-	4 [illegible]	[illegible].[illegible]1	4 [illegible]38	3.41	-	4 638	85.21	20[illegible] 5[illegible]	2 417	27[illegible] [illegible]75	3 273	2.26	54	213	6.50
Minneapolis, St. Paul & S.S. Marie, Inc.	12	1.[illegible]	291 895	[illegible].50	291 907	3.50	-	291 907	4 777.99	14 452 242	3 025	17 56[illegible] [illegible]	3 676	2.02	61	214	5.81
Northern Pacific	14[illegible]	2.02	370 759	3.66	37[illegible] [illegible]4	[illegible]	-	37[illegible] 904	9 18[illegible].98	26 634 981	[illegible]1	[illegible] 24[illegible] [illegible]7	4 274	1.39	4[illegible]	148	3.46
Spokane International	-	-	41 5[illegible]	3.64	41 505	3.64	-	41 505	178.30	52[illegible] 747	[illegible]2	434 461	2 437	7.94	[illegible]33	847	[illegible]4.7
Spokane, Portland & Seattle	-	-	120 776	4.24	120 776	4.24	-	120 776	1 1[illegible]	3 494 300	3 084	6 599 004	[illegible]	3.46	107	45[illegible]	7.76
Total	15 [illegible]4	1.47	2 812 025	3.69	2 827 [illegible]	3.88	* 465 923	[illegible] 80[illegible]	57 0[illegible]1.49	17[illegible] [illegible]1 79[illegible]	3 014	225 331 751	3 [illegible]	1.65	[illegible]	1[illegible]	[illegible]
Central Western Region:																	
Atchison, Topeka & Santa Fe	-	-	625 4[illegible]	2.98	625 432	2.98	-	625 432	19 572.46	[illegible]2 4[illegible]4 [illegible]4	3 193	150 409 057	7 [illegible]	[illegible]	[illegible]	[illegible]	1.24
Chicago, Burlington & Quincy	-	-	216 041	3.52	216 041	3.52	* 131 858	347 899	11 503.37	35 522 406	[illegible]	5[illegible] [illegible] 4[illegible]5	5 266	0.61	1[illegible]	[illegible]	1.[illegible]
Chicago, Rock Island & Pacific	-	-	2[illegible] [illegible]	2.80	29[illegible] 598	2.80	-	292 598	10 100.85	[illegible]	2 802	4[illegible] [illegible]4 [illegible]14	4 811	1.03	[illegible]	[illegible]	[illegible]
Colorado & Southern	-	-	24 [illegible]4	4.1[illegible]	24 174	4.10	* [illegible] 401	26 575	780.08	2 346 013	3 007	3 881 629	4 976	1.03	[illegible]1	1[illegible]7	2.56
Colorado & Wyoming	14[illegible]	2.88	1 412	[illegible].7[illegible]	1 554	3.65	-	1 554	106.13	342 [illegible]	3 228	51 020	481	[illegible].45	15	[illegible]	1[illegible]
Denver & Rio Grande Western	-	-	15[illegible] [illegible]	4.[illegible]	158 527	4.0[illegible]	* 2 552	161 079	3 088.3[illegible]	9 568 9[illegible]	3 098	17 639 061	5 7[illegible]	1.06	51	[illegible]	3.64
Fort Worth & Denver	-	-	107 008	4.07	107 008	4.07	* 3 411	11[illegible] 419	1 507.59	4 55[illegible] 31[illegible]	[illegible]24	5 558 840	3 687	[illegible].35	71	284	7.[illegible]3
Northwestern Pacific	192	2.05	41 [illegible]21	3.24	41 513	3.24	-	41 513	429.92	1 225 114	2 [illegible]	1 768 759	4 114	[illegible]	97	[illegible]	7.60
Pacific Electric	-	-	[illegible] 74	3.00	3[illegible] [illegible]74	3.00	-	32 074	539.40	1 843 200	3 417	355 623	[illegible]59	1.74	59	17[illegible]	27.03
Southern Pacific Co	[illegible]	2.73	[illegible]	3.76	[illegible]	3.7[illegible]	* 58[illegible]	759 150	11 979.58	3[illegible] 46[illegible] [illegible]	[illegible]44	114 663 354	[illegible] 57[illegible]	2.08	[illegible]	238	[illegible]
Toledo, Peoria & Western	-	-	1[illegible] [illegible]48	3.92	1[illegible] [illegible]	3.[illegible]	-	12 948	285.69	905 066	3 168	1 076 654	3 769	1.[illegible]	4[illegible]	17[illegible]	[illegible]
Union Pacific	5[illegible]	2.55	[illegible]7[illegible] 141	3.89	673 647	3.89	-	673 647	13 400.18	37 873 512	2 826	126 033 866	9 405	1.78	5[illegible]	196	2.08
Western Pacific	[illegible]5	[illegible].37	1[illegible] [illegible]	4.50	136 203	4.5[illegible]	* 1 651	137 854	1 560.58	4 650 425	2 980	11 991 240	7 [illegible]4	2.93	87	393	5.11
Total	2 137	2.65	3 078 146	3.57	3 080 283	3.57	* 142 459	3 222 742	74 854.13	226 099 376	3 021	54[illegible] [illegible]3 7[illegible]2	7 249	1.36	41	147	2.03
Southwestern Region:																	
Kansas City Southern	-	-	[illegible] 917	3.06	69 917	3.06	-	69 917	1 374.58	4 345 564	3 161	9 266 383	6 741	1.61	[illegible]1	155	2.31
Kansas, Oklahoma & Gulf	15	[illegible].1[illegible]	46 731	3.16	46 746	3.16	-	46 746	354.35	1 063 716	3 002	1 15[illegible] 446	3 264	4.3[illegible]	132	417	12.77
Louisiana & Arkansas	-	-	41 294	3.10	41 294	3.10	-	41 294	890.19	2 901 082	3 259	4 [illegible]54 331	5 116	1.42	46	144	2.81
Missouri-Kansas-Texas	-	-	92 765	3.11	92 765	3.11	-	92 765	3 520.67	11 198 367	3 181	13 127 144	[illegible] 72[illegible]	0.83	26	82	2.20
Missouri Pacific	112	1.26	907 783	3.10	907 895	3.10	-	907 895	11 805.27	36 412 802	3 084	6[illegible] 27[illegible] 1[illegible]	5 3[illegible]	2.4[illegible]	77	[illegible]	4.45
St. Louis-San Francisco	-	-	3[illegible] 747	3.26	3[illegible]3 747	3.26	-	3[illegible]3 747	5 815.06	18 291 424	3 146	27 265 627	4 689	1.99	63	2[illegible]4	4.34
St. Louis, San Francisco & Texas	-	-	11 096	3.43	11 09[illegible]	3.43	-	11 096	149.16	463 137	3 105	642 720	4 309	2.40	74	255	5.[illegible]
St. Louis Southwestern	-	-	151 565	3.08	151 565	3.08	* 2 486	154 [illegible]51	1 772.82	5 412 894	3 053	13 675 523	7 714	2.80	85	264	3.42
Texas & New Orleans	-	-	254 975	3.08	254 975	3.08	-	254 975	[illegible] 391.74	14 871 382	2 758	31 423 049	5 828	1.71	47	14[illegible]	[illegible]
Texas & Pacific	-	-	191 375	3.11	191 375	3.11	-	191 375	2 222.81	6 498 432	2 924	18 232 734	8 203	2.94	86	267	3.26
Texas Mexican	58	0.50	25 [illegible]	3.14	25 718	3.1[illegible]	-	25 718	240.98	762 261	3 163	263 512	1 094	3.37	107	335	3[illegible]
Total	185	1.09	2 156 9[illegible]8	3.13	2 157 [illegible]43	3.13	* 2 486	2 159 57[illegible]	33 537.63	102 221 061	3 048	182 882 571	5 453	2.11	64	201	3.69
Grand total - United States	177 571	2.04	15 054 118	3.71	15 231 689	3.69	* 797 869	16 029 558	320 815.95	965 111 756	3 008	1 923 470 211	5 996	1.58	47	175	2.92
[illegible]:																	
Canadian National	[illegible]7 926	1.61	3 067 377	2.91	3 103 303	2.89	-	3 103 303	29 327.	85 592 587	2 918	b	b	3.63	106	306	b
Canadian Pacific	[illegible]6 272	2.07	1 713 940	3.04	1 760 212	3.01	-	1 760 212	21 262.	61 254 481	2 881	91 235 734	4 230	2.88	[illegible]	250	[illegible].92
Ontario & Northland	-	-	110 544	4.29	110 544	4.29	-	110 544	666.13	1 974 605	2 900	2 723 634	4 089	5.72	166	712	1.7[illegible]

a Gross ton-miles of cars and contents, plus two times gross ton-miles of locomotives and tenders in freight service, plus three times gross ton-miles of locomotives and tenders in passenger service.
b Not reported.

Note: "Average cost" as shown in Columns 3, 5 and 7, represents storekeepers average cost of ties charged out and used. They are not the actual costs or prices paid for the ties purchased during the period.

Compiled by
Association of American Railroads, Bureau of Railway Economics, Washington, D.C.
from Annual Reports of Class I Railways to the Interstate Commerce Commission.

May 1959

Table B

NUMBER AND AGGREGATE COST OF NEW WOOD CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF NEW WOOD CROSS TIE RENEWALS TO TOTAL CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and large Canadian roads, by years, and for the average of five years 1954 to 1958, inclusive

Note: All figures are exclusive of bridge and switch ties

Road	Number of new wood cross tie renewals per mile of maintained track						Aggregate cost of new wood cross tie renewals per mile of maintained track						Per cent new wood cross tie renewals to all ties in tracks					
	1954	1955	1956	1957	1958	5 year average	1954	1955	1956	1957	1958	5 year average	1954	1955	1956	1957	1958	5 year average
NEW ENGLAND REGION:																		
Bangor & Aroostook	115	99	130	147	148	128	$339	$275	$384	$422	$454	$375	3.97	3.44	4.50	5.[illegible]	[illegible].14	4.43
Boston & Maine	57	23	28	22	20	30	222	89	107	85	76	115	1.93	0.78	.95	0.79	[illegible]	1.01
Canadian Pacific (lines in Me.)	71	52	73	70	82	70	264	198	270	261	302	259	2.45	1.80	[illegible]	[illegible]	2.86	2.3[illegible]
Central Vermont	75	75	90	96	81	83	338	339	405	463	415	342	2.52	2.5[illegible]	3.[illegible]4	3.[illegible]2	2.74	2.61
Maine Central	106	96	84	51	72	82	361	330	284	186	269	286	[illegible]	[illegible]	2.81	1.72	2.4[illegible]	[illegible]4
New York Connecting	76	70	155	2[illegible]9	138	134	372	343	767	1 130	67[illegible]	658	2.43	2.[illegible]	4.[illegible]	7.[illegible]0	4.3[illegible]	4.2[illegible]
New York, New Haven & Hartford	9	28	29	31	28	25	32	105	111	121	110	[illegible]	.29	.91	[illegible]	1.[illegible]	1.[illegible]5	0.85
Rutland	4	10	82	15	40	34	13	101	284	58	157	123	.13	0.96	2.63	0.47	1.27	1.[illegible]9
Total	49	45	52	46	47	48	177	158	184	167	175	172	1.64	1.49	1.[illegible]	1.5[illegible]	1.64	1.60
GREAT LAKES REGION:																		
Ann Arbor	1[illegible]4	61	62	47	39	63	401	229	222	181	170	241	3.41	2.0[illegible]	[illegible]3	1.56	[illegible]	[illegible]
Delaware & Hudson	58	49	61	58	33	52	218	152	165	174	61	1[illegible]4	1.77	1.53	2.01	1.[illegible]	1.[illegible]	1.[illegible]6
Delaware, Lackawanna & Western	50	44	40	79	66	76	251	388	360	349	314	332	1.94	3.03	2.69	2.49	2.08	2.49
Detroit & Toledo Shore Line	51	49	35	72	37	49	230	224	150	344	190	228	1.69	1.62	1.15	2.50	1.[illegible]7	1.65
Erie	74	58	62	56	19	54	268	225	242	214	76	205	2.50	1.39	2.1[illegible]	1.[illegible]	[illegible]	1.83
Grand Trunk Western	56	52	45	47	44	49	212	198	163	118	171	172	1.84	1.[illegible]6	1.43	1.50	1.3[illegible]	1.5[illegible]
Lehigh & Hudson River	60	62	69	70	66	65	256	261	290	144	336	297	2.21	2.29	2.56	2.58	[illegible].45	[illegible].42
Lehigh & New England	80	39	76	75	48	64	338	164	337	327	210	275	2.06	1.29	2.53	2.48	1.59	2.11
Lehigh Valley	64	44	53	44	27	46	252	161	196	149	87	169	2.13	1.44	1.76	1.4[illegible]	0.89	1.54
Monongahela	34	34	54	39	28	38	130	127	126	159	121	133	1.18	1.15	1.84	1.33	0.95	1.29
New York Central	54	78	56	62	22	54	200	257	180	211	67	183	1.75	2.52	1.80	1.99	[illegible].71	1.75
New York, Chicago & St. Louis	91	91	79	60	16	67	352	334	305	240	63	259	2.91	2.[illegible]4	2.53	1.94	0.50	2.16
New York, Susquehanna & Western	34	33	21	6	11	21	95	115	81	29	47	73	1.17	1.14	0.72	0.21	.36	0.72
Pittsburgh & Lake Erie	47	47	44	107	71	63	179	146	147	254	179	120	1.53	1.[illegible]4	1.45	3.[illegible]2	2.34	2.08
Pittsburgh & West Virginia	40	22	32	32	60	37	183	102	133	135	329	176	1.31	0.73	1.[illegible]4	1.[illegible]4	1.[illegible]6	1.[illegible]2
Wabash	68	64	38	38	40	50	270	262	165	174	183	211	2.18	2.03	1.21	1.20	1.27	1.[illegible]6
Total	62	70	58	58	28	55	234	249	204	209	101	199	2.31	2.28	1.87	1.90	0.91	1.79
CENTRAL EASTERN REGION:																		
Akron, Canton & Youngstown	136	120	63	65	3	81	507	413	249	375	11	311	4.60	4.06	2.12	2.[illegible]	0.[illegible]	[illegible].75
Baltimore & Ohio	44	78	69	66	49	61	131	261	232	226	172	204	1.53	2.74	2.44	2.30	1.6[illegible]	2.14
Bessemer & Lake Erie	33	22	65	72	80	54	144	64	267	289	361	225	1.02	0.6[illegible]	1.92	2.14	2.38	1.[illegible]
Central R.R. of New Jersey	51	50	41	28	17	37	200	182	130	97	56	133	1.52	1.74	1.45	[illegible].[illegible]2	[illegible].[illegible]2	1.32
Chicago & Eastern Illinois	45	5[illegible]	55	5	55	56	157	201	200	254	210	234	1.49	1.93	1.81	2.12	1.79	1.83
Chicago & Illinois Midland	11[illegible]	57	3[illegible]	39	38	57	393	239	130	145	135	208	3.70	1.[illegible]2	1.[illegible]9	1.24	1.26	1.5[illegible]
Detroit, Toledo & Ironton	96	111	77	57	25	73	333	381	256	207	97	255	3.34	[illegible].84	2.6[illegible]	1.09	0.85	[illegible].55
Elgin, Joliet & Eastern	18	24	21	40	12	23	54	68	71	150	48	78	0.60	[illegible].[illegible]3	0.69	1.30	[illegible]	0.74
Illinois Terminal	50	83	61	47	30	54	148	244	184	149	101	165	1.54	2.59	1.92	1.53	[illegible].[illegible]7	1.71
Long Island	78	72	69	63	53	67	291	270	307	290	243	280	2.70	2.50	2.39	2.17	1.[illegible]	[illegible]4
Missouri-Illinois	32	30	32	19	19	26	87	77	87	54	52	71	1.03	[illegible]	1.03	0.60	0.6[illegible]	0.74
Monon	65	85	172	73	51	75	212	276	328	240	169	245	2.10	2.73	3.28	2.34	1.05	2.42
Pennsylvania	42	55	62	67	40	53	155	196	232	284	175	208	1.45	1.93	2.17	2.35	1.40	1.8[illegible]
Penna.-Reading Seashore Lines	68	72	49	53	50	58	243	272	197	245	246	241	2.51	2.60	1.80	1.96	1.[illegible]4	2.15
Reading Company	44	45	54	52	17	42	167	169	205	209	71	164	1.58	1.61	1.96	1.86	0.61	1.[illegible]2
Staten Island Rapid Transit	42	79	30	48	8	43	150	228	166	237	45	165	1.65	3.10	1.40	1.87	0.29	1.06
Western Maryland	49	43	72	69	45	56	211	182	305	301	199	240	1.70	1.50	2.48	2.39	1.5[illegible]	1.92
Total	45	61	63	63	40	54	160	213	227	251	163	203	1.57	2.12	2.18	2.20	1.39	1.89
POCAHONTAS REGION:																		
Chesapeake & Ohio	55	56	40	47	13	42	185	197	148	175	49	151	1.80	1.86	1.31	1.54	0.45	1.39
Norfolk & Western	68	83	101	98	53	81	218	263	388	386	209	293	2.21	2.67	3.27	3.15	1.70	2.00
Richmond, Fredericksburg & Potomac	136	72	31	52	33	65	519	284	125	210	142	256	4.54	2.34	1.[illegible]2	1.70	1.08	2.14
Virginian	88	84	89	80	63	83	299	288	305	322	256	294	2.86	2.75	2.91	2.90	2.06	2.70
Total	64	67	62	66	30	58	213	227	233	252	116	208	2.08	2.19	2.04	2.15	0.98	1.84
SOUTHERN REGION:																		
Alabama Great Southern	82	76	64	71	54	69	282	286	240	320	245	275	2.72	2.53	2.10	2.34	1.80	2.30
Alabama Tennessee & Northern b	-	-	-	-	39	-	-	-	-	-	119	-	-	-	-	-	1.22	-
Atlanta & St. Andrews Bay	50	93	69	75	75	72	222	412	310	338	339	324	1.63	3.06	2.28	2.45	2.47	2.38
Atlanta & West Point	150	152	164	135	105	141	550	533	575	528	434	524	5.03	5.10	6.05	4.99	3.67	5.01
Atlantic Coast Line	87	103	97	85	76	90	299	342	339	310	292	316	2.80	3.30	3.12	2.72	2.44	2.88
Carolina & Northwestern a	-	-	136	84	39	-	-	-	593	339	163	-	-	-	4.98	2.91	1.32	-
Central of Georgia	109	103	127	107	99	109	340	312	394	349	339	347	3.77	3.55	4.40	3.70	3.42	3.77
Charleston & Western Carolina	213	176	225	217	160	198	821	692	979	930	687	822	7.27	6.00	7.64	7.37	5.44	6.74
Cincinnati, New Orleans & Tex. Pac.	90	70	70	76	79	77	340	26	281	355	340	316	3.04	2.38	2.37	2.59	2.68	2.61
Clinchfield	246	128	152	123	100	150	753	395	595	457	420	524	7.66	4.00	4.75	3.84	3.11	4.67
Florida East Coast	138	126	152	171	147	147	507	455	576	677	593	562	4.76	4.33	5.24	5.90	5.06	5.06
Georgia	159	147	165	151	136	152	538	491	553	537	514	527	5.22	4.84	5.43	4.98	4.49	4.99
Georgia & Florida	241	227	223	104	158	191	5[illegible]3	500	494	222	323	426	6.93	8.39	8.25	3.86	5.64	7.05
Georgia Southern & Florida	324	273	127	70	57	170	743	621	456	279	252	470	10.[illegible]9	6.69	4.03	2.21	1.82	5.41
Gulf, Mobile & Ohio	88	86	89	83	80	85	286	276	284	280	267	279	2.79	2.70	2.81	2.63	2.[illegible]2	2.69
Illinois Central	84	65	83	75	47	71	283	223	294	292	181	255	2.76	2.14	2.73	2.45	1.53	2.32
Louisville & Nashville (Inc. N.C.& St.L.)	103	73	92	78	69	83	323	228	289	256	241	267	3.63	2.58	3.24	2.75	2.43	2.93
New Orleans & Northeastern	66	62	68	76	66	68	260	270	269	368	340	301	2.22	2.[illegible]9	2.30	2.57	2.24	2.26
Norfolk Southern	216	208	197	170	116	181	501	491	467	465	365	458	7.39	7.10	6.71	5.85	3.98	6.21
Piedmont & Northern a	-	-	100	105	105	-	-	-	460	491	493	-	-	-	3.22	3.42	3.41	-
Savannah & Atlanta a	-	-	173	161	167	-	-	-	532	530	506	-	-	-	5.58	5.21	5.41	-
Seaboard Air Line	89	89	73	58	62	74	320	312	263	224	240	272	2.96	2.96	2.43	1.93	2.04	1.23
Southern Ry.	75	74	67	54	50	64	264	252	267	254	235	254	2.41	2.38	2.15	1.74	1.62	2.06
Tennessee Central	146	128	117	90	42	105	394	334	328	243	120	284	4.81	4.23	3.85	2.99	1.37	3.45
Western Ry. of Alabama	168	174	205	180	132	172	61[illegible]	607	718	702	545	637	5.60	5.82	6.84	6.01	4.40	5.73
Total	99	89	93	81	69	86	325	290	323	302	263	301	3.27	2.95	3.09	2.67	2.28	2.85

Table P

Sheet [illegible] of [illegible] sheets

[illegible] Class I Roads in the United States and Large Connecting Roads, by years, and for the average of the five years 1954 to 1958, inclusive

Note: All figures are exclusive of bridge and switch ties

Road	Number of new wood cross tie renewals per mile of maintained track						Aggregate cost of new wood cross tie renewals per mile of maintained track						Per cent new wood cross tie renewals to all ties in tracks					
	1954	1955	1956	1957	1958	5 year average	1954	1955	1956	1957	1958	5 year average	1954	1955	1956	1957	1958	5 year average
[illegible]																		
[illegible] Western Inc. (St. L. [illegible])	46	47	68	87	51	58	122	$174	$227	$316	$199	$214	1.20	1.59	2.27	2.94	1.73	1.95
[illegible] Western	4	92	95	112	44	70	214	305	310	393	343	313	1.82	3.08	3.18	3.73	3.15	2.94
[illegible] Chicago, St. Paul & Pacific	54	46	40	44	44	50	145	213	213	164	90	165	1.76	2.25	1.95	1.44	0.77	1.61
[illegible] Duluth & Iron Range	61	51	39	55	49	51	223	146	148	223	164	191	2.05	1.71	1.30	1.73	1.61	1.70
[illegible] North Shore & Atlantic	138	114	134	106	91	121	454	415	426	348	330	400	4.77	4.86	4.53	3.53	3.07	4.14
[illegible] Pacific	57	42	42	41	45	44	183	146	156	151	92	146	1.9	1.73	1.55	1.71	1.13	1.56
Great Northern	74	68	68	57	61	7	285	268	265	251	266	271	2.36	2.18	2.17	1.82	1.93	2.09
[illegible] Western	153	140	135	96	60	120	853	401	460	220	67	406	8.78	4.53	4.7.	2.09	.70	4.16
[illegible] St. Louis	54	65	79	76	58	70	155	193	253	222	163	197	1.79	2.17	2.65	2.52	2.18	2.26
[illegible] Hartfield & Southern a	137	131	100	92	75	108	417	368	290	244	271	329	4.59	4.39	3.33	3.00	2.64	3.60
[illegible]	-	-	67	112	54	-	-	-	284	523	213	-	-	-	2.40	4.74	2.26	-
[illegible] St. Louis & [illegible] Marie (Inc. [illegible])	93	91	99	89	61	86	310	290	291	281	214	277	3.10	2.99	3.28	2.93	2.02	2.86
[illegible]	54	44	42	46	40	45	180	147	150	169	148	159	1.79	1.49	1.45	1.59	1.39	1.54
[illegible] International	481	244	224	334	233	301	1555	792	698	1235	847	1031	16.14	8.14	7.02	11.42	7.94	10.30
[illegible] Portland & Seattle	61	81	96	87	107	82	236	245	368	365	452	331	1.99	1.98	3.10	2.83	3.46	2.67
Total	64	64	68	66	50	62	208	221	244	246	192	222	2.05	2.13	2.24	2.20	1.65	2.05
[illegible]																		
Atchison, Topeka & Santa Fe	64	79	79	57	32	62	193	244	244	181	95	192	1.99	2.49	2.46	1.79	1.00	1.95
Chicago, Burlington & Quincy	41	35	4	41	19	35	136	116	134	139	66	112	1.34	1.14	1.30	1.33	0.61	1.14
Chicago, Rock Island & Pacific	71	68	65	61	29	59	193	178	181	166	81	201	2.46	2.28	2.17	2.05	1.03	2.00
Colorado & Southern	53	44	46	45	31	45	176	163	171	171	127	162	1.76	1.63	1.63	1.48	1.03	1.51
Denver & Rio Grande Western	72	28	27	74	15	57	682	99	107	308	54	250	4.74	0.80	0.86	2.38	0.45	1.5
Fort Worth & Denver	64	72	93	65	71	73	229	192	247	246	208	225	1.75	1.55	2.08	1.66	1.66	1.74
Northwestern Pacific	208	251	147	139	97	168	716	811	576	490	313	581	7.23	8.72	5.11	4.88	3.39	5.87
Pacific Electric b	-	-	-	-	59	-	-	-	-	-	178	-	-	-	-	-	1.74	-
Southern Pacific Co.	79	74	61	62	63	68	253	253	238	242	238	245	2.61	2.43	2.02	2.05	2.08	2.24
[illegible] Pacific & Western	58	52	60	21	45	55	324	185	237	85	178	202	3.08	1.63	1.90	0.68	1.43	1.74
Union Pacific	58	72	65	60	50	59	171	250	239	229	196	217	1.76	2.56	2.31	2.11	1.78	2.10
Western Pacific	148	147	115	108	87	121	603	599	549	555	393	546	4.97	4.94	3.84	3.63	2.93	4.06
Total	64	60	66	58	41	60	204	225	226	208	147	202	2.10	2.28	2.17	1.89	1.36	1.96
[illegible]																		
[illegible] Southern	46	95	56	54	51	63	136	280	212	166	155	190	1.44	3.01	2.14	1.71	1.61	1.98
Kansas, Oklahoma & Gulf	106	113	140	149	132	128	315	334	367	398	417	366	3.55	3.80	4.66	4.97	4.39	4.27
Louisiana & Arkansas	94	81	63	59	46	69	295	234	187	185	144	209	2.89	2.49	1.95	1.81	1.42	2.11
[illegible] Arkansas-Texas	94	94	105	191	26	103	290	264	292	579	72	261	3.11	2.98	3.32	6.00	0.83	3.25
Missouri Pacific	114	114	100	72	77	96	324	335	244	228	239	274	3.69	3.71	3.45	2.42	2.49	3.11
St. Louis-San Francisco	84	87	90	73	63	79	243	243	256	223	204	234	2.98	2.73	2.86	2.35	1.99	2.52
St. Louis, San Francisco & Texas	74	112	48	59	74	77	219	313	192	200	255	236	2.39	3.58	2.17	1.69	2.40	2.49
St. Louis Southwestern	74	100	81	97	85	87	221	301	258	307	264	270	2.38	3.21	2.93	3.13	2.80	2.83
Texas & New Orleans	106	102	87	57	47	80	268	279	233	162	146	218	3.84	3.70	3.12	2.05	1.71	2.78
Texas & Pacific	128	128	140	120	86	121	375	380	436	387	267	369	4.43	4.38	4.79	4.11	2.94	4.13
Texas Mexican	120	94	108	109	107	108	421	275	324	336	335	338	3.80	2.96	3.43	3.45	3.37	3.40
Total	101	104	97	88	64	91	287	297	279	268	201	206	3.35	3.39	3.16	2.88	2.11	2.98
[illegible] United States	70	73	72	67	47	66	230	242	247	243	175	227	2.31	2.33	2.38	2.22	1.58	2.18
[illegible]																		
Canadian National	118	112	117	116	106	113	354	345	356	347	306	341	4.06	3.84	3.98	3.94	3.63	3.89
Canadian Pacific	1[illegible]	92	87	86	83	91	337	304	278	274	250	289	3.52	3.18	2.93	3.00	2.88	3.10
[illegible]	233	194	238	156	166	197	966	862	1026	677	713	849	8.03	6.69	8.20	5.29	5.72	6.78

a Not Class I prior to January 1, 1956. Data for prior years not available.
b Not Class I prior to January 1, 1958. Data for prior years not available.

Note: Missouri Pacific Lines includes: Beaumont, Sourlake & Western, New Orleans, Texas & Mexico, St. Louis, Brownsville & Mexico, San Antonio, Uvalde & Gulf, and International-Great Northern (1956 consolidation).

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Advance Report of Committee 30—Impact and Bridge Stresses
D. W. Musser, *Chairman*

Tests of Timber Trestles on the Santa Fe Railway

A. DIGEST

This report contains a description and analysis of data obtained during a test of two double-track ballasted-deck timber bridges on the Santa Fe Railway near Powell, Ariz. These locations were chosen because the low relative humidity in that area insured the low moisture content in the wood desired for these tests.

Stresses were obtained in the stringers and piles of each bridge. Stringer deflections were also measured. Traction and braking forces were determined by measurement of bending in the piles, pressure of bulkhead against the embankment and stress in the running rails.

A review of the analysis of the data obtained develops the following salient features:

1. Live Load Distribution to the Stringers

The simultaneous live-load stresses were not distributed uniformly to the stringers. The stringers nearer the center of the bridge carried the larger percentage of the load while the stringers nearer the outside carried a smaller proportion of the load (see Figs. 7 to 10, incl.).

2. Maximum Total Stresses and Impact

The maximum total stresses shown on Figs. 11 to 22, incl., were generally below the calculated static stresses at midspan. The maximum total impacts shown on Figs. 23 to 26 were generally less than 20 percent.

3. Continuous Action

Two-span stringers with staggered joints act as continuous stringers. (See Figs. 3 to 6, incl.)

4. Duration of Stress

The cumulative effect of car loading on duration of stress appears to be of greater importance than the diesel locomotive loading.

The Seaboard Air Line test previously reported developed indications that the allowable working stresses, for ordinary trestles currently used in design work, might be increased. This present test provides further indications that such increase may be justified (see Figs. 34 to 39, incl.)

5. Deflections in Stringers (See Figs. 29 and 30)

The maximum recorded net deflections in the bridges were as follows:

Bridge 558.8	Eastbound	0.11 in
	Westbound	0.12 in
Bridge 559.2	Eastbound	0.12 in
	Westbound	0.07 in

6. Piles

The live loads were not uniformly distributed to the piles but rather tended to follow a parabolic distribution with those toward the center carrying the largest proportions of the load (see Figs. 27 and 28).

7. Braking and Traction Tests

Such tests produced only relatively low bending stresses in piles, thus justifying the assumption usually made that such stresses may be neglected in the design of structures similar to those in this test. As indicated below most of the longitudinal forces are transmitted to the rails. Traction forces were much less than braking forces (see Figs. 31 and 32).

8. General

A review of the entire test develops that all the bridges are capable of carrying heavier loading than subjected to in the test.

B. FOREWORD

Committee 30 has an assignment for the study of stresses in timber structures and previously has reported on stresses in a few timber trestle approaches in conjunction with steel bridge tests. Early in 1954 it was recognized that a program should be adopted having as its sole purpose the testing of timber structures. A field testing program was, therefore, developed covering trestles of ordinary construction and including a sufficient number of structures to establish adequate ranges of stress, and variations in span length, height and distribution of loads.

Since the strength of wood is, in part, dependent upon its moisture content, the geographical location of trestles to be tested is of importance. The choice made for these tests was influenced by the constancy of the Arizona climate during the test period.

The Santa Fe Railway suggested several possible locations and the two selected are both near Powell, Ariz. Both are accessible for the test truck, which was placed alongside each of the trestles. Instruments required in the test were installed in the truck. The tests were made in March and April 1957.

The general procedure in conducting these tests was the same for both trestles. The SR–4 strain gages and other recording devices were placed on the various members of the trestle and each was individually calibrated.

The complete test of each trestle was divided into the following series:

Series 1—Stringer stresses and deflections—westbound
Series 2—Stringer stresses and deflections—eastbound
Series 3—Pile stresses—eastbound and westbound
Series 4—Stresses due to braking and traction—westbound

The test of bridge 558.8 extended over a two-week period and with the exception of series 4 was made with regular trains, some trains being operated at requested speeds. Series 4 was made with a test train operating under controlled conditions.

The test of bridge 559.2 was made during a two-week period subsequent to the test on bridge 558.8, and with the exception of series 4 was made with regular trains, some trains being operated at requested speeds. Series 4 was made with a test train operating under controlled conditions.

These tests were conducted for AREA Committee 30—Impact and Bridge Stresses, and were carried out under the general direction of G. M. Magee, director of engineering research, Engineering Division, AAR; the funds necessary for the tests and analysis of the data were provided by the AAR.

The conduct of the tests, analysis of data and preparation of the report were under the direction of E. J. Ruble, research engineer structures, assisted in the field by F. P.

Drew, assistant research engineer structures, and M. F. Smucker, assistant electrical engineer. The office work was under the direction of D. W. Wilki, chief draftsman, assisted by W. G. Byers and J. S. Nardi, structural engineer and assistant structural engineer, respectively. This report was prepared by L. R. Morgan, assistant research engineer structures.

C. INSTRUMENTS

The instruments used in the tests to determine strains in the various members of the trestles consisted principally of two 12-channel oscillographs, SR–4 strain gages, deflection coils and pressure cells, all of which were used in a manner similar to that outlined in the tests of timber trestles on the Seaboard Air Line Railroad, as published in AREA Proceedings, Vol. 60, page 143.

D. TEST SPANS AND LOCATION OF GAGES

Bridge 558.8

This structure (shown in photograph 2) is a five-span treated-timber ballast-deck pile trestle located near Powell, Ariz., on the railroad's main line between Seligman and Needles. The bridge for the eastbound track was built in 1909 and for the westbound in 1923. The trestle crosses a ravine. There is no evidence that high water in the ravine has caused damage, although there has been damage due to wash from the adjacent Sacramento Wash which closely parallels the main track. As shown in Fig. 1, the span lengths are nearly equal; the total length of the five spans is 69 ft 0 in (both eastbound and westbound). Under each track the bents consist of six driven piles of Douglas fir and longleaf pine. The caps are 12 by 14 in. There are twelve 8- by 13-in, four 10- by 10-in, four 6- by 10-in and one 8- by 10-in Douglas fir stringers and ballast timbers under the eastbound track, and seventeen 8- by 16-in shortleaf pine stringers under the westbound track. Stringers under the eastbound main are butted, with staggered joints, as shown on Fig. 3.

Reinforcing plates have been placed on the bottoms of several of the stringers under the eastbound track. These plates are 3 by 8 in and extend the full length of the stringers, face to face of caps. They are securely fastened to the stringers with drive spikes and split-ring shear developers. Stringers under the westbound main are arranged to form a combination lap-type and butt-type deck with several of them extending beyond the face of the cap, as shown in Fig. 4. Deck planks are 3 in by 10 in by 14 ft 0 in, used under the westbound track only, there being none over the stringers under the eastbound. The distances from base of rail to top of deck planks and to top of stringers are 2 ft 7½ in and 2 ft 8½ in, respectively. Ballast-retaining timbers, size 6 by 8 in, in the required number are in place on the eastbound and westbound tracks. The center line of the eastbound and westbound decks are approximately at the respective center lines of tracks.

Strains were measured on the bottoms of the stringers at the center line of spans 4 and 5 on both eastbound and westbound decks and on the tops of the stringers over the center line of bent 5, as shown on Fig. 3 (to place strain gages on the tops of the stringers, it was necessary to remove the ballast between two cross ties and install shallow bulkheads to expose the stringers, as shown in photograph 1). Use was also made of a deflection-measuring device consisting of a movable core surrounded by a coil of wire; deflection in a stringer resulted in the movement of the core, thereby changing the flux of the magnetic field, thus recording the change on the oscillograph which is calibrated to show resultant deflections. Pressure cells were used behind the backwall

Photograph 1—Ballast removed to permit placement of gages on stringers at center line of bent.

Photograph 2—Santa Fe bridge 558.8.

timber on bent 6 to measure pressure at that point. The axial stress in the running rails was determined by strain gages placed as shown in Sections AA and FF on Fig. 4.

Bridge 559.2

This structure (shown in photograph 3) is an eight-span treated-timber ballast-deck pile trestle. The bridge for the eastbound track was built in 1909 and for the westbound in 1923. The bridge crosses a ravine in which water flows south to Sacra-

Photograph 3—Santa Fe bridge 559.2.

mento, Wash. As shown in Fig. 1, the span lengths are nearly equal; the total length of the eight spans under the eastbound track is 109 ft 4 in and 111 ft 2 in under the westbound. The bents consist of five driven longleaf piles under each track, plus one pile common to both tracks. The caps are 12 by 14 in. There are twelve 8- by 14-in and eight 10- by 10-in Douglas fir stringers and ballast timbers under the eastbound track, the 10- by 10-in timbers resting on shims to make them level with the 8- by 14-in timbers. On the bottoms of several of the stringers in spans 7 and 8 there are reinforcing plates as described for bridge 558.8. There are seventeen 8- by 16-in Douglas fir stringers under the westbound track. Arrangement of stringers is the same as for bridge 558.8, as is also the use of 3- by 10-in deck planking under the westbound track only. The distance from base of rail to top of stringers (eastbound) is 2 ft 0½ in and to top of deck planks (westbound) is 2 ft 1 in.

Strains were measured on the bottoms of the stringers at the center lines of spans 7 and 8 on both the eastbound and westbound tracks and on the tops of the stringers over the center line of the bents, as shown in Fig. 5 (to place strain gages on the tops of the stringers, it was necessary to remove the ballast between two cross ties and install shallow bulkheads to expose the stringers). As at bridge 558.8, use was made of a deflection device to measure deflection in stringers. Pressure cells were used behind the backwall timbers on bent 9 to measure the pressure at that point. The axial stress in the running rails was determined by strain gages placed as shown in Sections AA and FF on Fig. 6.

E. TEST TRAINS

As mentioned above, regular trains under normal operation, except for certain controlled speeds, were used on all series for bridge 558.8, except for series 4 for which a test train of two 2650 Class diesel locomotives and eight cars (approximately 500 tons) was used. Similar procedure was followed on bridge 559.2, except that for series 4 the test train consisted only of two 2650 Class diesel locomotives. Diesel locomotives

only are used in this territory, and those recorded during these tests are shown diagrammatically in Fig. 2. The axle loads and spacings shown were furnished by the railroad.

Diesel Electric, Two-Axle Locomotives (Classes as Shown in Fig. 2)

These locomotives are used principally for freight service. Their ratings in terms of Cooper loading for moment at the center of a 13-ft 8-in simple span varies from E 40 to E 42.

F. ANALYSIS OF RECORDS

A discussion of stress corrections, moisture content and specific gravity is contained in the report on the Seaboard Air Line Railroad tests previously mentioned, to which reference is made for general information. The moisture content for the two Santa Fe bridges ranged from 7 to 12 percent; detailed information relative to moisture content is shown below in conjunction with specific gravity and modulus of elasticity for the respective species at the time of the tests. It should be noted that the tests under consideration were in connection with wood having a moisture content below the saturation point; therefore, an adjustment for moisture content must be made in arriving at the modulus of elasticity. This adjustment was made on the basis of information furnished by the Forest Products Laboratory and the method is shown below.

Modulus of Elasticity

The Wood Handbook No. 72, published by the Forest Products Laboratory, presents relationships between moisture content, specific gravity and modulus of elasticity in compression parallel to the grain. These relationships are used to adjust certain tabular values of modulus of elasticity to determine values of the test specimens.

The moisture content adjustment was made with the following equation:

$$\log E_3 = \log E_1 + \frac{M_1 - M_3}{M_1 - M_2} \log \frac{E_2}{E_1}$$

which reduces to

$$E_3 = E_1 \left(\frac{E_2}{E_1}\right)^{\frac{M_1 - M_3}{M_1 - M_2}}$$

where M_1 = moisture content of green wood,
E_1 = modulus of elasticity of green wood,
M_2 = moisture content of 12-percent wood,
E_2 = modulus of elasticity of 12-percent wood,
M_3 = moisture content of wood of test specimens,
E_3 = modulus of elasticity of wood of test specimens.

The specific gravity correction was made with this equation:

$$E_T = E_3 \left(\frac{G_T}{G_S}\right)^{1.25}$$

where E_T = Compression modulus of elasticity of test specimens,
G_T = Specific gravity of test specimens—at oven-dry weight and volume,
G_S = Specific gravity tabular values—at oven-dry weight and volume.

Tabular values furnished by the Forest Products Laboratory are as follows:

	M_1 %	E_1 ksi	M_2 %	E_2 ksi	G_S
Douglas fir, coast	24	2,018	12	2,279	0.508
Pine, longleaf	21	1,935	12	2,229	0.623
Pine, shortleaf	25	1,680	12	2,936	0.535

Using these tabular values and correcting to the moisture contents and specific gravities of the test specimens the following values were obtained:

TABLE 1

	M_3 %	E_3 ksi	G_T	E_T ksi
For Bridge 558.8—WBM				
1. Stringers—shortleaf pine	7	2,043	0.530	2,021
2. Piles—longleaf pine	9	2,335	0.611	2,275
For Bridge 558.8—EBM				
3. Stringers—Douglas fir, coast	7	2,395	0.551	2,645
4. Piles—Douglas fir, coast	12	2,279	0.594	2,770
For Bridge 559.2—WBM				
5. Stringers—Douglas fir, coast	8	2,375	0.559	2,677
6. Piles—longleaf pine	12	2,229	0.644	2,325
For Bridge 559.2—EBM				
7. Stringers—Douglas fir, coast	8	2,375	0.545	2,594
8. Piles—longleaf pine	9	2,337	0.687	2,643

The above values of E_T (multiplied by 10^3) represent the corrected values of modulus of elasticity which were used to convert recorded strains into stress.

G. STATIC AND DYNAMIC EFFECTS

The oscillograph deflections, when multiplied by the proper stress factors, were tabulated and then analyzed for the purpose of determining the magnitude of the static stresses, total impacts, maximum live-load-plus-impact stresses and other dynamic effects of the moving loads, including the stresses developed from braking and traction.

1. Static Stresses in Stringers

The recorded static stress in the bottom fibers of the stringers at the center of the test spans is shown in Tables 2 and 3. The calculated stress is shown for each of two assumptions: (1) simple span stringers and (2) continuous stringers. The positioning of locomotives for each case of calculated stress was determined from the criteria for maximum stress at center of span. The entire live load was assumed to have been distributed equally to 12 deep stringers for the eastbound track for each bridge, and to 15 stringers for the westbound track, the outside stringer being disregarded.

The recorded static stress in each stringer for each static speed run is shown. The maximum stress value is then compared with the calculated value in the form of a stress factor. The average stress factor appears in the columns at the right. It is seen that all recorded values are less than those calculated, except for bridge 559.2 westbound.

The extreme static stress recorded on bridge 558.8 was 691 psi, and the stress factor was 0.741. On bridge 559.2 the values were 752 psi and 0.706, respectively. The calculated stresses, based on the assumption of a simple span, are seen to be invariably higher than the recorded stresses because the circumstance of simple spans did not actually obtain; the continuity of the stringers rather sharply decreased the stresses. The calculated stresses, based on continuity of the stringers, is likewise seen to agree more nearly with the recorded stresses, as would be expected. While it is common practice to use

continuous stringers, usually no advantage is taken in design of the effect of the continuity in reducing the positive moments.

The recorded static stress at center line of bents for each bridge is shown in Table 4. Also shown in this table are the calculated negative bending moment stresses and the corresponding stress factors. The positioning of locomotives for each case of calculated stress was determined from the criteria for maximum stress over center of bent. The live load was considered distributed equally to 12 stringers in the eastbound bridges (six of which were continuous over the bent), and to 15 stringers in the westbound bridges (all of which were continuous over the bent). It can be seen that in nearly all cases the stress factors are greater than unity, indicating that recorded values are higher than calculated. It is also interesting to note that the ratios of negative to positive bending moment stress are also greater than unity in nearly all cases. This indicates that in the design of such stringers consideration should be given to the stress produced by the negative bending moment.

2. Simultaneous Maximum Stresses in Stringers

The simultaneous maximum stresses in the stringers at center of spans and over the bents are shown in Figs. 7, 8, 9 and 10. Each of these figures contain graphs showing:

Recorded static stresses across width of deck,

Recorded moving load (above 10 mph) stresses,

Calculated stresses, based on simple span analysis, and

Calculated stresses based on assumed continuity analysis with train in position which produced simultaneous maximum stress.

The gage numbers shown in Figs. 7, 8, 9 and 10 correspond to those shown in Figs. 3, 4, 5 and 6, respectively, to which figures reference is given for details of location.

Bridge 558.8—Eastbound and Westbound

It can be seen from the graphs, Figs. 7 and 8, that the distribution of static stress is such that the outside stringers have low stresses and that the stringers toward the center of the bridge carry the highest stress. The locomotives used in this test on this bridge were Santa Fe Class 200. Comparison of calculated static stress with recorded static stress confirms the effect of continuity in reducing the stress below that which would be the case if simple beam analysis is used.

Bridge 559.2—Eastbound and Westbound

The distribution of stresses across the deck as shown on Figs. 9 and 10 is very similar to that for bridge 558.8. A more uniform distribution of stress is observed under the westbound than under the eastbound, both at center of span and over the bent.

3. Maximum Recorded Stresses in Stringers

The maximum stresses due to live load plus impact recorded in the stringers are shown for various speeds and for each stringer on which gages were placed. Stresses are shown for two adjacent spans and the intermediate bent. The several classes of locomotives involved in the test, with one exception, do not vary more than 4 percent in their respective weights nor is there any considerable difference in axle spacing; therefore, it is not considered necessary to differentiate between locomotives insofar as plotting resultant stresses is concerned.

Bridge 558.8—Eastbound

The presence of reinforcing plates on the bottom of stringers 35 and 36, Fig. 11, appears to explain the low values of the stress indicated. Since these plates are securely fastened to the stringers, they are partially effective in increasing the section modulus. The low values of stresses in stringer 32 may, in a measure, be due to its position near the outside. The maximum stress in span 4 was 554 psi.

Fig. 12 indicates a distribution of stresses tending to be more uniform, with a considerable amount in the stringers toward the outside. Low values are for stringer 13 which is reinforced with a plate. The maximum stress in span 5 was 747 psi. Fig. 13 shows considerable variation in stress values, with the maximum over bent 5 being 1155 psi.

Bridge 558.8—Westbound

Westbound span 4, shown in Fig. 14, indicates a stress distribution tending to be uniform; this may, in part, be due to the planking across the top of the stringers and partly to the considerable depth of ballast. The maximum stress in this span was 483 psi. Span 5, shown in Fig. 15, likewise indicates a trend to uniform distribution of stresses, with a maximum of 429 psi. Fig. 16 indicates a distribution of stresses with higher values toward the center of the track; the maximum stress was 584 psi over bent 5.

Bridge 559.2—Eastbound

The distribution, as shown in Fig. 17, indicates that the 10- by 10-in timbers on the outside were not stressed to the same extent as the 8- by 14-in stringers. The maximum stress in the stringers in span 7 was 772 psi. The distribution in span 8, Fig. 18, is similar to that for span 7, with a maximum of 713 psi. The stresses over bent 8, Fig. 19, have a distribution generally of a parabolic nature, with a maximum of 1041 psi.

Bridge 559.2—Westbound

Fig. 20 shows the distribution to be fairly uniform under the track, but with somewhat less recorded stress toward the outer stringers. The maximum stress in span 7 was recorded as 562 psi. Span 8, Fig. 21, likewise indicates a fairly uniform distribution of stresses, though somewhat less toward the outer stringers, with a maximum of 660 psi. Fig. 22 shows a uniform distribution of stresses over bent 8 except that stringer 29 has materially higher stresses even though there is planking across the top of the stringers. The maximum stress over bent 8 was 775 psi.

A general trend toward higher stresses at speeds above 10 mph appears in some instances, but it is not consistent for both bridges. The recorded stresses are less than the calculated stresses except as shown on Fig. 21 for gage numbers 11, 12 and 13. However, in all cases the amount of excess stress as recorded is very little over the calculated figure.

4. Total Impacts in Stringers

The recorded total impacts in the stringers of bridge 558.8 are shown in Fig. 23 (eastbound) and Fig. 24 (westbound) and similarly for bridge 559.2 in Fig. 25 (eastbound) and Fig. 26 (westbound). The impacts are shown as percentages of the average recorded static stresses at the centers of spans or at the centers of the bents. The total impact percentage in each test run for a particular speed and locomotive is the increase in stress in the member over the average stress occurring at speeds of about 10 mph and less.

The recorded impacts are shown for only two of the continuous stringers in each bridge. The two stringers selected were those which had high recorded maximum stresses.

AREA design specifications for timber bridges make no separate allowance for impact, therefore, no attempt was made to indicate the various effects which are combined in the total impact.

It can be seen from Figs. 23 to 26, incl., that with few exceptions the recorded total impacts in the stringers were less than 20 percent. The maximum value recorded was 26.6 percent which occurred under a Class 200 locomotive at 21 mph in the eastbound bridge 558.8.

5. Maximum Stresses in Piles

The recorded maximum stresses in the piles of bents 4 and 5 under the westbound track of bridge 558.8 are shown in Fig. 27, and similarly for the piles of bents 7 and 8 under the westbound track of bridge 559.2 in Fig. 28. Gages were placed on the piles as shown in the respective figures. The recorded stresses for each gage are shown on the figures.

It is noted that there was little difference in the resultant stresses shown on the diagrams for tests made under braking conditions compared to those without braking. However, there was in some cases considerable difference between stresses on opposite sides of the piles, reflecting an unequal distribution of the direct loads.

Bridge 558.8

The diagrams on Fig. 27 indicate that the distribution tended to place least stress on the outside piles and the highest stress on the inner piles.

The average pile diameter at the gages is 13⅛ in. The maximum stress recorded under braking was 327 psi at 46 mph, while that developed with no braking was 325 psi at 47 mph. No stress was recorded at gages 48 and 49 because the cap did not bear on this pile.

Bridge 559.2

The diagrams on Fig. 28 indicate a roughly parabolic stress distribution, except that the maximum stresses developed were not quite as high as those on bridge 558.8. The average pile diameter at the gages is 14$\frac{5}{16}$ in. The maximum recorded stress under braking was 267 psi at 45 mph compared to 288 psi at 38 mph under no braking. No stress was recorded at gages 48 and 49 because the cap did not bear on this pile.

The maximum recorded stresses in the pile as indicated by these tests are low, but they are comparable to the allowable stresses perpendicular to the grain on the cap. Such allowable stresses may govern the permissible load on the pile.

6. Recorded Deflection of Stringers

The maximum recorded net deflections of stringers as shown in Figs. 29 and 30 are as follows:

Bridge 558.8

Eastbound—0.11 in (stringer on which gage 33 is located)
Westbound—0.12 in (stringer on which gage 41 is located)

Bridge 559.2

Eastbound—0.12 in (stringer on which gage 33 is located)
Westbound—0.07 in (stringer on which gage 42 is located)

It is noted that the maximum stresses, maximum deflections and speeds do not show

any correlation. This may be explained by the injection of a fourth factor—the degree of fixity at the supports. Since the latter is variable, its relationship is indefinite. There was no observed increase in deflection with increase in speed, which is in line with recorded stress in relation to speed.

7. Stresses Produced by Longitudinal Forces

The test train was also used to determine the effect on the structure of the train braking to a stop on the bridge at various locations and accelerating off it. In this series of tests, stresses were recorded for the westbound of each of the two bridges, the gages being placed on the piles as close to the ground as possible on each of two bents under the respective decks. Gages were also placed on the rail at each end of the westbound track only on both bridges, and pressure cells were placed at the west end of both bridges. The runs for this phase of the test were all westbound.

The general character of the stresses produced in the piles and rails by stopping and starting the test train on each of the bridges is shown on Figs. 31 and 32 for bridges 558.8 and 559.2, respectively. The general elevation of each bridge is shown at the top of each figure.

Bridge 558.8—Westbound

The recorded stresses in the piles of bents 4 and 5 are shown on the left hand side of the tabulation on Fig. 31. Two stress values are shown for each run; the top figure is the maximum unit stress in the pile from direct load on the pile and the bottom figure is the maximum recorded bending unit stress from the longitudinal force. The direct stress is shown to indicate the relative magnitude of the bending stress.

It can be seen that the average direct stress was not exceeded by the bending stresses. The maximum direct stress was 280 psi, run 121.

The maximum stresses from braking occurred during run 115 when the test train stopped 38 ft 2 in west of the west end. It can be seen that the pile bending stresses averaged about 34 psi. The gages on the bents were located 37.5 in below the top of the cap. The average pile diameter is 13.125 in and its section modulus is 222 in^3. The force required to produce a bending stress of 34 psi in this pile is

$$P = \frac{222 \times 34}{37.5} = 200 \text{ lb or } 1000 \text{ lb per bent.}$$

The stresses in the rail for run 115 at the west end of the bridge were — 1020 and — 1150 psi and at the east end + 1090 and + 980. The rail on the westbound bridges is 136 lb section, continuously welded, which has an area of 13.35 in.^{2} Assuming this stress spread over the total area, the total compressive force transmitted by the rails at the west end was $(1020 + 1150) \times 13.35 = 29{,}000$ lb. At this same instant, tensile stresses at the east end induced a total tensile force of 26,700 lb. The total longitudinal force carried by the rails was 55,700 lb. This represents 16 percent of the total weight on the bridge, consisting of all axles from the last axle of the first diesel unit, the second unit and the first axle of the car.

Pressure cells recorded 0.25 and 0.48 psi for an average of 0.36 psi during the run. This means that the bridge was being pushed against the embankment by a longitudinal force. Assuming that the pressure was distributed on a bulkhead area represented by the approximate 5 ft depth of the bulkhead and the approximate 14 ft width of the bridge deck for a total area of 70 sq. ft, the total pressure was $0.36 \times 70 \times 144 = 3{,}630$ lb.

Comparing the longitudinal force of 55.7 kips carried by the rails, 3.6 kips carried by the embankment and the 6 kips carried by the 6 bents, it can be seen that most of the total longitudinal force from braking went into the rails.

Bridge 559.2—Westbound

As in bridge 558.8, it can be seen from Fig. 32 that the average direct stress was not exceeded by the bending stresses. The maximum direct stress was 275 psi, run 327. The maximum stresses from braking occurred during run 331, where the average bending stress in the piles was 35 psi. The distance below the top of the cap to the gages was 3 ft 1½ in. The average pile diameter of 14.31 in has a section modulus of 287 in.^{3} Hence the force required to produce a bending stress of 35 psi is:

$$P = \frac{287 \times 35}{37.5} = 268 \text{ lb or } 1{,}340 \text{ lb per bent.}$$

The rail stresses in run 331 at the west end was found to be —1126 and —1293 psi and the rail stress in the east end +1946 and +2048 psi. The total compressive force transmitted by the rail is thus calculated to be 32.3 kips, while the total tensile force at the east end was 53.3 for a total longitudinal force of 85.6 kips. This represents 17 percent of the total weight on the bridge of the two diesel units.

The pressure cells recorded pressures of 0.27 and 0.38 psi for an average of 0.33 psi. The total pressure on 70 sq ft of bulkhead is thus 0.33 x 70 x 144 = 3330 lb. It can be seen that most of the total longitudinal force from braking went into the rails.

Several tractive runs were made, i.e., starting on the bridge, and the resulting stresses are tabulated at the bottom of Fig. 32. The bending stresses determined in the bents were quite low. The highest values of stress carried by the one rail was 563 psi during run 338. It can be noted that there was a slight relief of the compressive stress on the pressure cells, indicating movement of the bridge opposite to that during the braking runs.

8. Duration of Stress in Stringers

The AREA Proceedings, Vol. 60, page 143 contains data on the relationship between actual duration of live-load stress and the magnitude of this stress. Further data are presented here on this relationship.

Fig. 33 shows a typical ocillogram on which only two traces are shown; the upper trace represents stress at gage 12 at center of span during the passage of a Class 200 Santa Fe diesel locomotive. The locomotive at the top of the figure is shown in position which produced the stress indicated at point C. The lower trace represents stress at gage 29, over the center of the bent, during the passage of this same locomotive. The locomotive at the bottom of the figure is shown in position which produced the stress indicated at point D.

The stringer on which these gages were placed is 8 by 16 in and located close to the center line of one rail. The stringer is about 28 ft long and is continuous over one bent, as shown. The measured stresses at gage 12 are thus principally tensile and result from a positive bending moment at the center of the span. The measured stresses at gage 29 are, of course, also tensile resulting from the negative bending moment over the bent. Tensile strains are indicated on these oscillograms as a downward deflection of the trace. These trace deflections are measured from a base line, or zero stress level, taken before the locomotive reaches the stringer on which these gages are placed.

In addition to stress the oscillogram shows time duration by the timing lines at the top and bottom of the record. These lines are spaced on the actual oscillogram 0.01 sec apart, but for clarity only 0.10 sec lines are indicated.

The two traces shown are of quite a different character. That for gage 12 indicates that after each truck or pair of trucks had crossed the span the stress at gage 12 returned to zero (or slightly into compression). The trace for gage 29, however, indicates

that as long as the locomotives were over the bent the stress at 29 did return to zero, but fluctuated between a maximum tensile stress and a lower tensile stress.

The maximum static stress at gage 12 (upper oscillograph trace) is shown to be 494 psi and this is taken to be 100 percent on the ordinate scale. For gage 29 the maximum static stress was 660 psi with the 100 percent ordinate scale at this stress level. If the axle loads on Fig. 33 had been heavy enough to produce the design stresses, the shape of the oscillograph trace would have been the same as shown, since the shape of the trace is primarily dependent on the axle spacing and the span length and not on the axle loads. The 100 percent static stress level can thus be considered the same as the design live-load stress.

Duration of load and stress must be associated together, and it was for this reason that stress levels were established, based on the static stress, and indicated by the horizontal lines at the 50, 60, 70. 80, 90, 100 and 110 percent ordinates of Fig. 33. The duration of stress was then determined at each gage location and at each of the above stress levels. For instance, on the upper trace the total duration of 50 percent of static stress is then the sum of line lengths a–b, c–d, e–f, g–h and a portion of line i–j. For this particular run the total loading time was about 2.0 sec for the four units, or only 0.5 sec per unit. It can readily be seen that at the higher stress levels the duration of stress becomes much less, and at the 100 percent level the loading time per unit is practically zero. On the lower trace the total duration of stress was determined similarly. However, it is apparent here that the 50 percent level of live-load stress was maintained for 3.0 sec for the full length of the locomotive, or 0.75 sec per unit.

This method of determining the duration of stress was also applied to car loading since the information was available from oscillograms, some of which were taken under entire trains and some only under cars near the head end of trains.

Figs. 34 to 39, incl., are individually marked to show the bridge number, location of span or bent and locomotive class for the respective diagrams.

Two of the continuous stringers were selected from each bridge and cumulative loading time determined for each class of locomotive and each run at the various stress levels from 50 to 110 percent of static stress. Three separate tabulations were made for each stringer, at the center of each span and over the center of the bent. The static stress was determined for each gage location (which was also the 100 percent stress level and which was used for all runs at that gage location and for the runs involving that locomotive.) An average time duration was then made at each gage location, each stress level and for each locomotive. This average included all speeds from the static speeds of less than 10 mph to the highest speeds. These average durations were plotted and appear on Fig. 34 to 39. It can be seen that all the curves are similar. As the stress level is reduced the cumulative loading time increases.

The information shown on Figs. 34 to 39 can be used to obtain the following maximum durations:

Percent of Live-Load Design Stress	*Diesel Locomotive Unit*	*Car*
50	2.42 sec	0.41 sec
60	2.28 sec	0.19 sec
70	1.66 sec	0.10 sec
80	1.15 sec	0.07 sec
90	0.69 sec	0.04 sec
100	0.19 sec	0.01 sec
110	0.01 sec	0.01 sec

Assuming that the trains tested are reasonably representative of the general traffic that will be carried throughout the life of the structure, herein taken at 50 years, and assuming that there will be an average of 25 trains per day, each having a three-unit locomotive and 100 cars, the total cumulative loading time in days at any stress level can be obtained by adding

$$\frac{25 \times 50 \times 365 \times 3}{86{,}400} \times \text{duration for a diesel unit}$$

to

$$\frac{25 \times 50 \times 365 \times 100}{86{,}400} \times \text{duration for a car.}$$

The results are shown on Fig. 40 on which is also shown the allowable stress in percent of stress for long-time loading.

It appears from Fig. 40 that an appreciable increase in allowable flexural working stresses for railway loading could be made. However, because the data are based only on these four tests, a specific recommendation for increasd stresses is not justified at this time.

H. CONCLUSIONS

The following statements are believed to be reasonable conclusions from the test data presented in this report. The moisture content of the timber was quite low, varying from 7 to 12 percent, reflecting the climatic conditions of Arizona.

Stringers

1. Static Stresses

The live load is not uniformly distributed laterally in the manner assumed by design specifications. Stringers located toward the center of the track carry a greater proportion of the load than those away from the center but within the length of tie plus twice the depth of ballast; this is of significance since the depth of ballast in these tests was much greater than is ordinarily used.

Timbers of shallower depth than stringers, placed to the outside primarily to retain the ballast, carry no appreciable live load.

Maximum static bending stresses at midspan were found to be less than calculated on the assumption of simple spans, and generally less or only slightly greater than calculated on the assumption of continuous spans. A maximum static stress of 752 psi was recorded.

Some maximum negative static bending stresses over intermediate bents were found to be greater than calculated. A maximum static stress of 1014 psi was recorded.

Timber plates securely attached to the bottom of stringers for reinforcing defective members can be made effective to carry load.

2. Impact and Maximum Total Stresses

Impacts were less than 20 percent of average static stress, with little exception. There may or may not be an increase in impact effect with an incrasee in speed.

Maximum total stresses were generally well below the static stresses calculated at midspan on the assumptions made as to effective stringers, and computed as simple spans; the maximum live-load stress measured in a stringer was 772 psi at midspan. Substantially higher stresses were recorded in the eastbound track bridges than in the westbound, due to a difference in design.

Maximum total stresses measured over bents were generally higher than at midspan and exceeded the calculated static stress for the adjacent midspan; a maximum stress of 1155 psi was recorded.

3. Continuous Action

Continuous action in the stringers of two-span length was substantial and effectively reduced stresses below that to be expected in the simple spans, as assumed in present design practice.

4. Duration of Stress

The cumulative loading time of cars in trains represented by these tests appears to be greater at all stress levels than that of locomotives. The combined cumulative loading time throughout the life of timber stringers in ordinary service appears to be of such relatively short duration as to permit an appreciable increase in unit working stresses over that allowed for long-time loading.

5. Deflection

Maximum net deflection from live load measured in several selected stringers was 0.12 in. There was no definite increase in deflections with increase in speed.

Piles

Maximum direct stresses in piles near the ground line were 325 psi and 288 psi, respectively, in the two trestles where strains were measured; in each case however the cap did not bear on an inside pile of the bent due to improper framing, thus increasing the load carried by the other piles. Unit stresses in piles of trestles of ordinary height are of interest particularly to the extent they may approximate unit bearing stresses of the caps on the piles.

The distribution of live loads to piles was not uniform; the outer piles carried less load than other piles in the bents.

Longitudinal Forces

Severe braking produced only low bending stresses in the piles of these ballasted-deck trestles. The maximum average bending stress measured in a bent was 35 psi. The longitudinal force was determined to be carried principally in the rails and transmitted to the roadbed beyond the bridges.

Traction forces measured were negligible.

TABLE 2

SANTA FE TIMBER TRESTLE TEST
COMPARISON OF RECORDED AND CALCULATED
STATIC STRESSES AT CENTER OF SPAN

Diesel Class	Bridge 558.8 EBM									Maximum Calculated Static Stress		Stress Factor Max Rec / Max Calc			
	Gage Number for Span 5*											Simple Span		Continuity	
	17	15	13	12	11	10	9	8	6	Simple	Continuity		Avg		Avg
200	571	644	231	397	624	471	471	580	333	889	760	0.724	0.73	0.847	0.85
	571	655	236	390	630	347	476	577	376			0.736		0.861	
	574	643	246	400	649	502	490	613	370			0.729		0.854	
2650	537	652	238	393	691	509	502	663	432	932	798	0.741	0.72	0.866	0.85
	541	652	221	373	691	520	513	669	403			0.741		0.866	
	586	664	247	406	678	520	495	661	403			0.727		0.850	
	568	639	228	384	660	496	487	661	397			0.709		0.829	
	568	658	253	393	652	513	520	655	409			0.705		0.825	
	Gage Number for Span 4*														
	37	36	35	34	33	32									
200	411	168	233	351	451	152				943	760	0.478	0.49	0.594	0.61
	446	186	233	381	465	54						0.493		0.612	
	471	182	227	384	467	52						0.499		0.619	
2650	498	182	253	414	498	45				989	798	0.503	0.51	0.624	0.63
	498	188	253	423	507	51						0.512		0.636	
	485	182	253	423	507	51						0.512		0.636	
	490	205	266	425	524	65						0.529		0.656	
	479	188	247	397	493	45						0.498		0.618	
	Bridge 558.8 WBM														
	Gage Number for Span 5*														
	16	15	14	12	11	10	9								
16	270	285	310	271	362	261	260			595	494	0.608	0.61	0.734	0.73
37	225	250	259	234	314	228	238			582	483	0.539	0.54	0.651	0.65
200	267	287	306	277	354	269	259			571	474	0.619	0.61	0.746	0.74
	293	313	328	294	359	269	272					0.628		0.757	
	277	298	307	278	339	245	257					0.593		0.715	
	Gage Number for Span 4*														
	45	44	43	42	41	40	39								
16	202	352	367	308	312	262	252			631	494	0.581	0.58	0.744	0.74
37	219	373	383	329	329	278	255			617	483	0.620	0.62	0.794	0.79
200	230	368	404	322	317	276	245			607	474	0.665	0.66	0.853	0.85
	249	394	399	338	349	289	278					0.657		0.841	
	240	378	399	336	328	278	266					0.657		0.841	

* See Figs. 3 and 4 for location of gages. All stresses in psi.

TABLE 3

SANTA FE TIMBER TRESTLE TEST
COMPARISON OF RECORDED AND CALCULATED
STATIC STRESSES AT CENTER OF SPAN

Diesel	Bridge 559.2 EMB									Maximum Calculated Static Stress		Stress Factor Max Rec / Max Calc			
	Gage Number for Span 8*											Simple Span		Continuity	
Class	16	15	14	13	11	9	8	7	5	Simple	Continuity		Avg		Avg
16	556	589	559	603	601	620	670	487	273	1056	892	0.634	0.63	0.751	0.75
200	512 538	543 573	518 551	549 584	585 582	600 598	642 639	476 460	251 259	1015	858	0.632 0.629	0 63	0.749 0.745	0 75
700	524	563	530	584	589	614	651	488	268	1030	868	0.631	0.63	0.750	0.75
2650	559 527 559 527 565 512	584 565 609 571 596 554	567 530 567 543 560 529	636 574 636 593 623 573	640 579 640 604 640 600	666 629 666 634 647 614	232 232 232 226 232 235	526 494 520 501 520 490	268 257 268 262 262 248	1064	897	0.625 0.591 0 625 0.595 0 608 0.576	0 60	0.743 0.701 0.742 0.706 0.721 0.684	0 72
	Gage Number for Span 7*														
	36	35	34	33	32	30									
16	329	391	461	661	557	259				1056	892	0.625	0.63	0.741	0.74
200	344 344	400 400	468 474	673 640	554 529	323 304				1015	858	0.663 0.630	0 65	0.784 0.746	0 77
700	353	411	479	628	534	248				1030	868	0.609	0.63	0.724	0.72
2650	381 362 369 362 375 356	433 413 427 433 433 441	507 494 501 513 513 532	725 706 699 752 717 732	590 584 578 603 584 590	256 243 256 263 256 274				1064	897	0.681 0.663 0.656 0.706 0.673 0.687	0.68	0.809 0.786 0.779 0.839 0.800 0.816	0.80
	Bridge 559.2 WBM														
	Gage Number for Span 8*														
	16	14	13	12	11	10	9								
16	350 355	398 453	526 529	492 513	489 483	388 401	410 407			620	513	0.848 0.853	0.85	1.025 1.031	1.03
200	338 338	450 456	505 492	492 489	529 505	417 413	439 420			595	494	0.889 0.848	0.87	1.071 1.022	1.04
700	331	447	491	477	499	401	425			604	500	0.826	0.83	0.998	1.00
	Gage Number for Span 7*														
	45	44	43	42	41	40	39								
16	431 445	428 459	429 455	483 492	418 410	402 398	281 311			620	513	0.779 0.793	0 79	0.942 0.960	0 95
200	442 443	439 442	445 439	494 504	453 437	415 396	322 306			595	494	0.830 0.847	0.84	1.000 1 020	1.010
700	432	437	450	502	466	415	327			604	500	0.831	0 83	1 005	1 005

* See Figs 5 and 6 for location of gages All stresses in psi.

TABLE 4

SANTA FE TIMBER TRESTLE TEST

RECORDED STATIC STRESS AT CENTER OF BENT

Diesel	Gage Numbers for Bent 8*						Maximum Recorded Static (f) At Center of Span (A)	Maximum Calculated Static (f) At Center of Bent (B)	Ratio (C)+ / (A)		Ratio (C)+ / (B)	
Class	27	26	25	24	23	22				Avg		Avg
Bridge 559.2 EBM												
16	681	889	1014	996	--	725	670	823	1.513	1.513	1.232	1.23
200	648 647	832 856	964 989	937 950	911 911	692 680	673 640	808	1.432 1.545	1.489	1.192 1.222	1.21
700	468	651	732	738	766	582	651	783	1.176	1.176	0.979	0.98
2650	537 499 554 499 554 491	739 733 739 739 746 716	870 870 870 882 870 849	812 793 799 812 812 798	788 782 776 807 788 801	623 629 598 636 623 625	725 706 699 752 717 732	808	1.200 1.232 1.244 1.172 1.213 1.159	1.203	1.078 1.078 1.078 1.091 1.078 1.050	1.08
Bridge 559.2 WBM												
	Gage Numbers for Bent 8*											
	33	31	30	29	28	27	26					
16	431 445	428 459	429 455	483 492	418 410	402 398	281 311	526 529	474	0.918 0.930	0.924	1.019 1.039	1.03
200	442 443	439 442	445 439	494 504	453 437	415 396	322 306	529 505	465	0.933 0.998	0.966	1.061 1.082	1.07
700	432	437	450	502	466	415	327	502	451	1.000	1.000	1.113	1.11
Bridge 558.8 EBM												
	Gage Numbers for Bent 5*											
	29	28	27	26	25	24						
200	812 806 856	647 699 794	454 493 524	501 569 593	1008 1079 1139	780 828 836	644 655 649	746	1.565 1.647 1.755	1.656	1.350 1.448 1.528	1.44
2650	800 773 755 748 787	661 661 641 622 647	496 504 378 467 492	512 523 482 485 490	994 929 909 973 984	688 683 683 728 677	691 691 678 661 658	746	1.438 1.344 1.340 1.472 1.495	1.418	1.331 1.245 1.219 1.302 1.319	1.28
Bridge 558.8 WBM												
	Gage Numbers for Bent 5											
	33	32	31	29	28	27	26					
16	264	315	415	520	441	301	401	367	474	1.416	1.416	1.098	1.10
37	240	294	373	461	409	313	398	383	471	1.203	1.203	0.980	0.98
200	261 273 277	333 354 335	410 443 422	510 559 508	434 450 425	309 346 304	415 440 399	404 399 399	465	1.262 1.401 1.273	1.292	1.098 1.201 1.092	1.13

* See Figs. 5, 6, 3 and 4 for location of gages. ** See Tables 3 and 2.
+(C) Maximum recorded static stress (f) at center of bent. All stresses in psi.

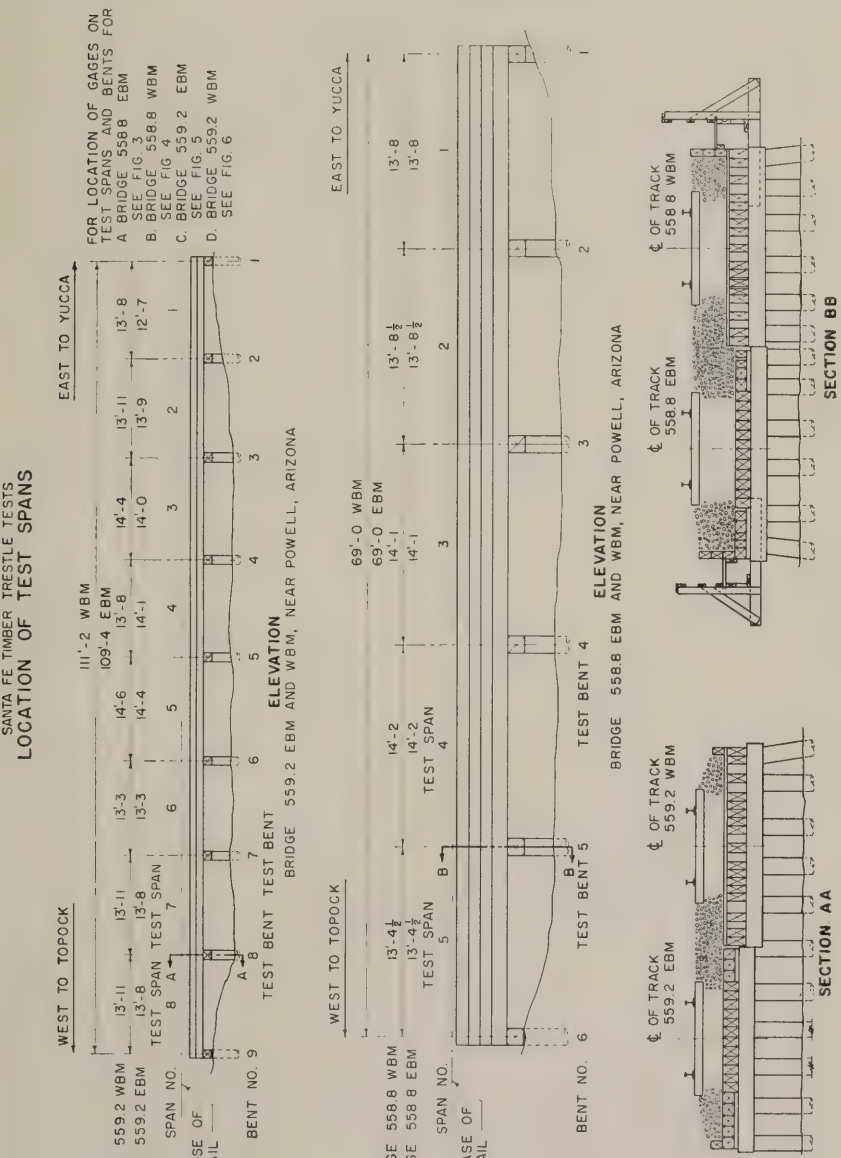
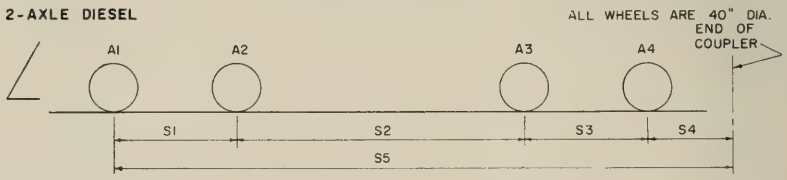


FIG I
SANTA FE TIMBER TRESTLE TESTS
LOCATION OF TEST SPANS
WEST TO TOPOCK
EAST TO YUCCA
FOR LOCATION OF GAGES ON TEST SPANS AND BENTS FOR
A BRIDGE 558.8 EBM SEE FIG. 3
B. BRIDGE 558.8 WBM SEE FIG 4
C. BRIDGE 559.2 EBM SEE FIG. 5
D. BRIDGE 559.2 WBM SEE FIG. 6
111'-2 WBM
109'-4 EBM
BRIDGE 559.2 WBM
BRIDGE 559.2 EBM
SPAN NO.
BASE OF RAIL
BENT NO. 9
TEST SPAN
TEST BENT
ELEVATION
BRIDGE 559.2 EBM AND WBM, NEAR POWELL, ARIZONA
69'-0 WBM
69'-0 EBM
BRIDGE 558.8 WBM
BRIDGE 558.8 EBM
BENT NO. 6
TEST BENT 4
TEST BENT 5
ELEVATION
BRIDGE 558.8 EBM AND WBM, NEAR POWELL, ARIZONA
℄ OF TRACK 558.8 WBM
℄ OF TRACK 558.8 EBM
SECTION BB
℄ OF TRACK 559.2 WBM
℄ OF TRACK 559.2 EBM
SECTION AA

FIG. 2
SANTA FE TIMBER TRESTLE TESTS
LOCOMOTIVE DATA

2-AXLE DIESEL



LOCO. CLASS	LOCOMOTIVE NUMBERS	AXLE WEIGHT - KIPS				AXLE SPACING - FEET				
		A1	A2	A3	A4	S1	S2	S3	S4	S5
16	16 TO 36	59.0	58.9	64.8	64.7	9'-0	21'-0	9'-0	5'-6	44'-6
37	37 TO 47	59.4	59.2	63.2	63.1	9'-0	21'-0	9'-0	5'-6	44'-6
100	100 TO 199	57.3	57.3	56.4	56.4	9'-0	18'-3	9'-0	4'-4	40'-7
200	200 TO 289 AND 200C TO 289C	62.2	62.2	62.2	62.2	9'-0	21'-0	9'-0	5'-6	44'-6
300	300 TO 314	59.0	59.1	63.2	62.7	9'-0	21'-0	9'-0	5'-6	44'-6
700	700 TO 725	61.4	61.6	62.8	63.2	9'-0	22'-0	9'-0	8'-1	48'-1
2650	2650 TO 2654, 2848 AND 2879 TO 2873	65.2	65.2	63.7	63.7	9'-0	22'-0	9'-0	7'-11½	47'-11½
2655	2655 TO 2847, 99 AND 2849 TO 2878	62.7	62.1	62.1	61.4	9'-0	22'-0	9'-0	7'-11½	47'-11½

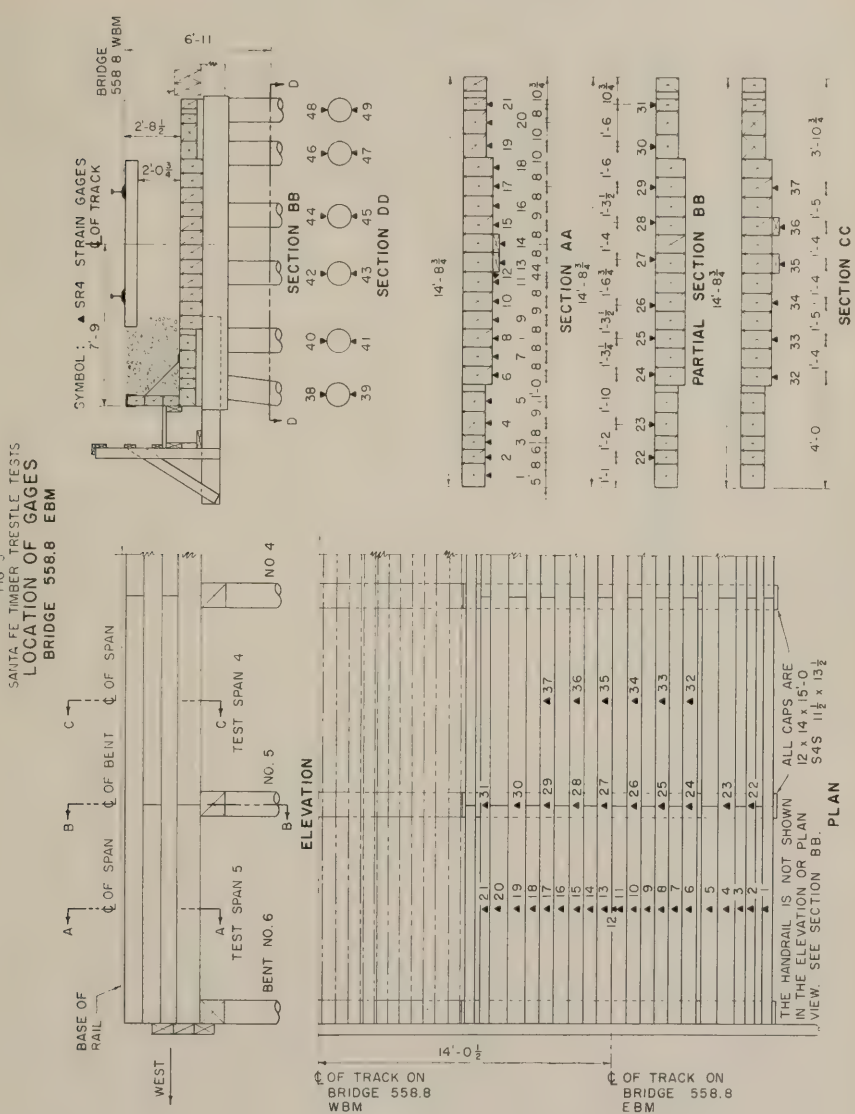


FIG 3
SANTA FE TIMBER TRESTLE TESTS
LOCATION OF GAGES
BRIDGE 558.8 EBM
SYMBOL : ▲ SR4 STRAIN GAGES
℄ OF TRACK
BRIDGE 558.8 WBM
SECTION BB
SECTION DD
SECTION AA
PARTIAL SECTION BB
SECTION CC
BASE OF RAIL
WEST
℄ OF SPAN
℄ OF BENT
TEST SPAN 4
TEST SPAN 5
BENT NO. 6
NO. 5
NO. 4
ELEVATION
PLAN
THE HANDRAIL IS NOT SHOWN IN THE ELEVATION OR PLAN VIEW. SEE SECTION BB.
ALL CAPS ARE 12" x 14" x 15'-0 S4S 11½" x 13½"
℄ OF TRACK ON BRIDGE 558.8 WBM
℄ OF TRACK ON BRIDGE 558.8 EBM

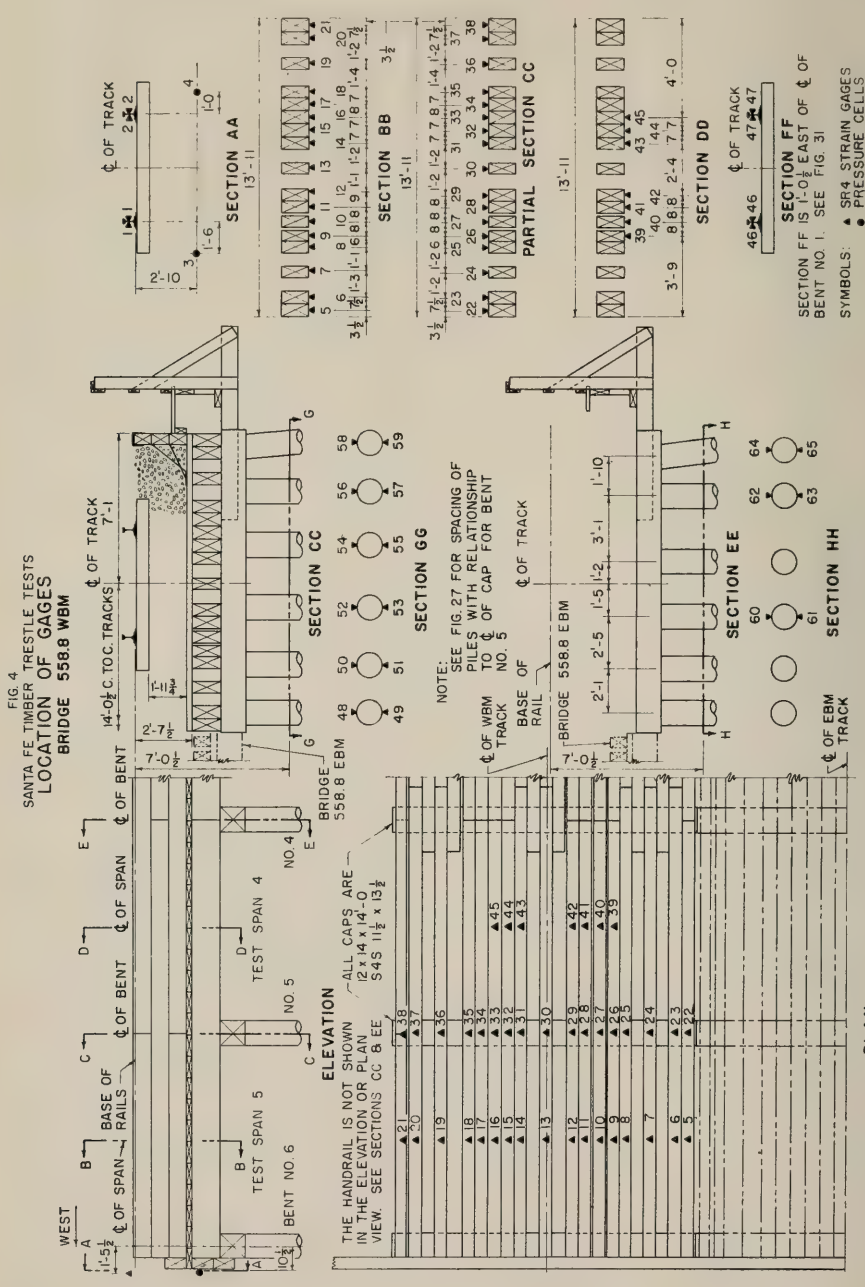


FIG. 4
SANTA FE TIMBER TRESTLE TESTS
LOCATION OF GAGES
BRIDGE 558.8 WBM
ELEVATION
PLAN
SECTION AA
SECTION BB
PARTIAL SECTION CC
SECTION DD
SECTION EE
SECTION FF
SECTION GG
SECTION HH
SECTION FF IS 1-0½ EAST OF ℄ OF BENT NO. 1. SEE FIG. 31
SYMBOLS: ▲ SR4 STRAIN GAGES
● PRESSURE CELLS
NOTE: SEE FIG. 27 FOR SPACING OF PILES WITH RELATIONSHIP TO ℄ OF CAP FOR BENT
ALL CAPS ARE 12 x 14 x 14'-0 S4S 11½ x 13½
THE HANDRAIL IS NOT SHOWN IN THE ELEVATION OR PLAN VIEW. SEE SECTIONS CC & EE
BRIDGE 558.8 EBM
BRIDGE 558.8 WBM
℄ OF TRACK
℄ OF BENT
℄ OF SPAN
BASE OF RAILS
TEST SPAN 4
TEST SPAN 5
BENT NO. 6
NO. 4
NO. 5
WEST

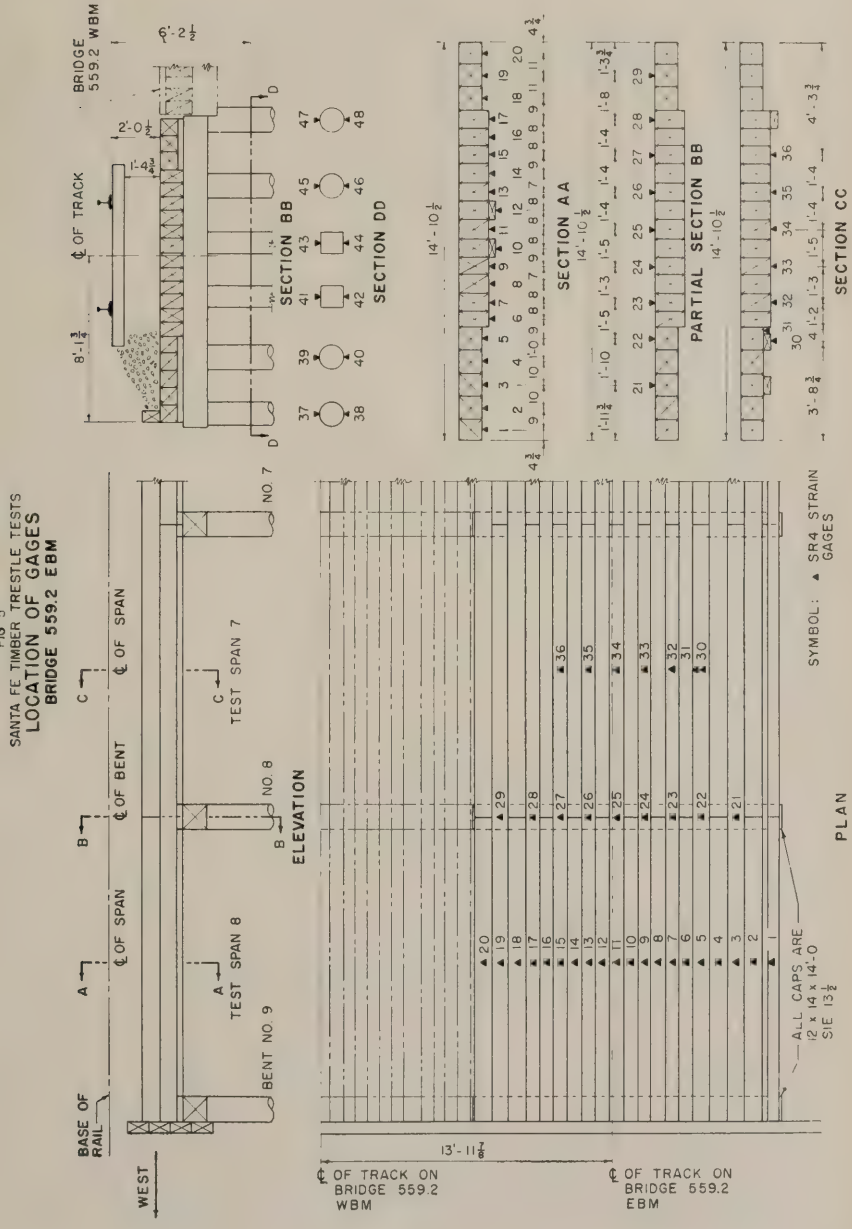


FIG 5
SANTA FE TIMBER TRESTLE TESTS
LOCATION OF GAGES
BRIDGE 559.2 EBM

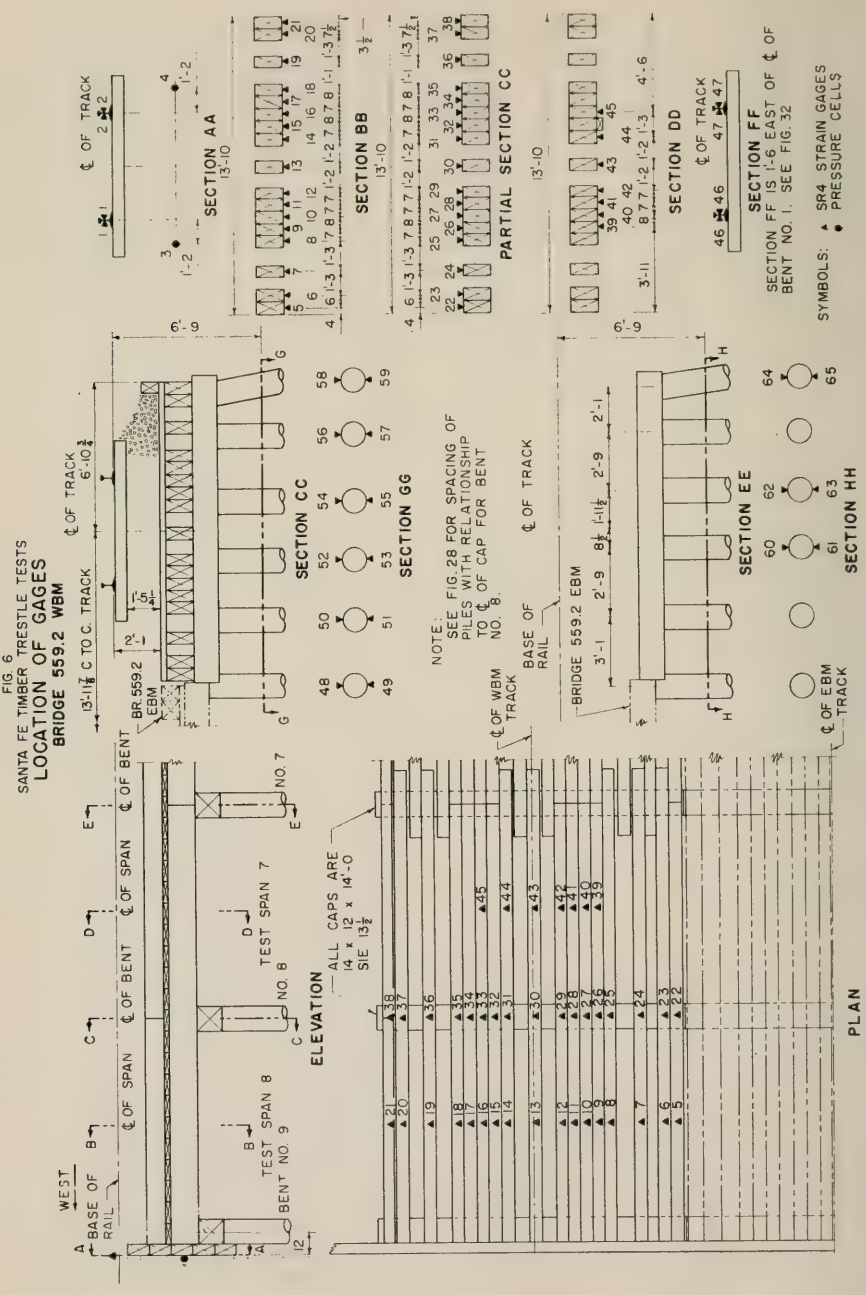


FIG. 6
SANTA FE TIMBER TRESTLE TESTS
LOCATION OF GAGES
BRIDGE 559.2 WBM
WEST
BASE OF RAIL
℄ OF SPAN
℄ OF BENT
TEST SPAN 7
TEST SPAN 8
BENT NO. 9
NO. 8
NO. 7
ELEVATION
ALL CAPS ARE 14 x 12 x 14'-0 SIE 13½
℄ OF TRACK
13'-11⅞ C TO C. TRACK
BR. 559.2 EBM
SECTION AA
SECTION BB
PARTIAL SECTION CC
SECTION DD
SECTION FF
SECTION FF IS 1'-6 EAST OF ℄ OF BENT NO. 1. SEE FIG. 32
SYMBOLS: SR4 STRAIN GAGES
PRESSURE CELLS
SECTION CC
SECTION GG
SECTION EE
SECTION HH
NOTE: SEE FIG. 28 FOR SPACING OF PILES WITH RELATIONSHIP TO ℄ OF CAP FOR BENT NO. 8.
℄ OF WBM TRACK
℄ OF EBM TRACK
BRIDGE 559.2 EBM
PLAN

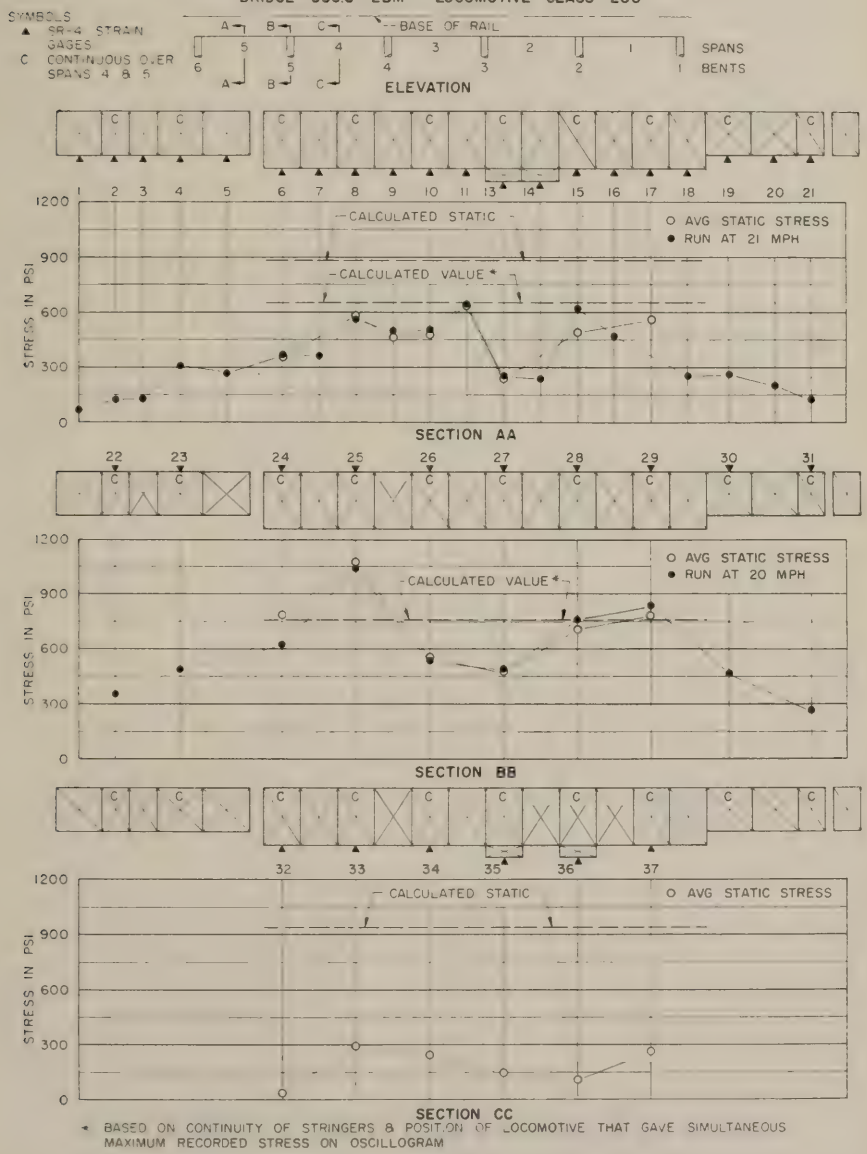
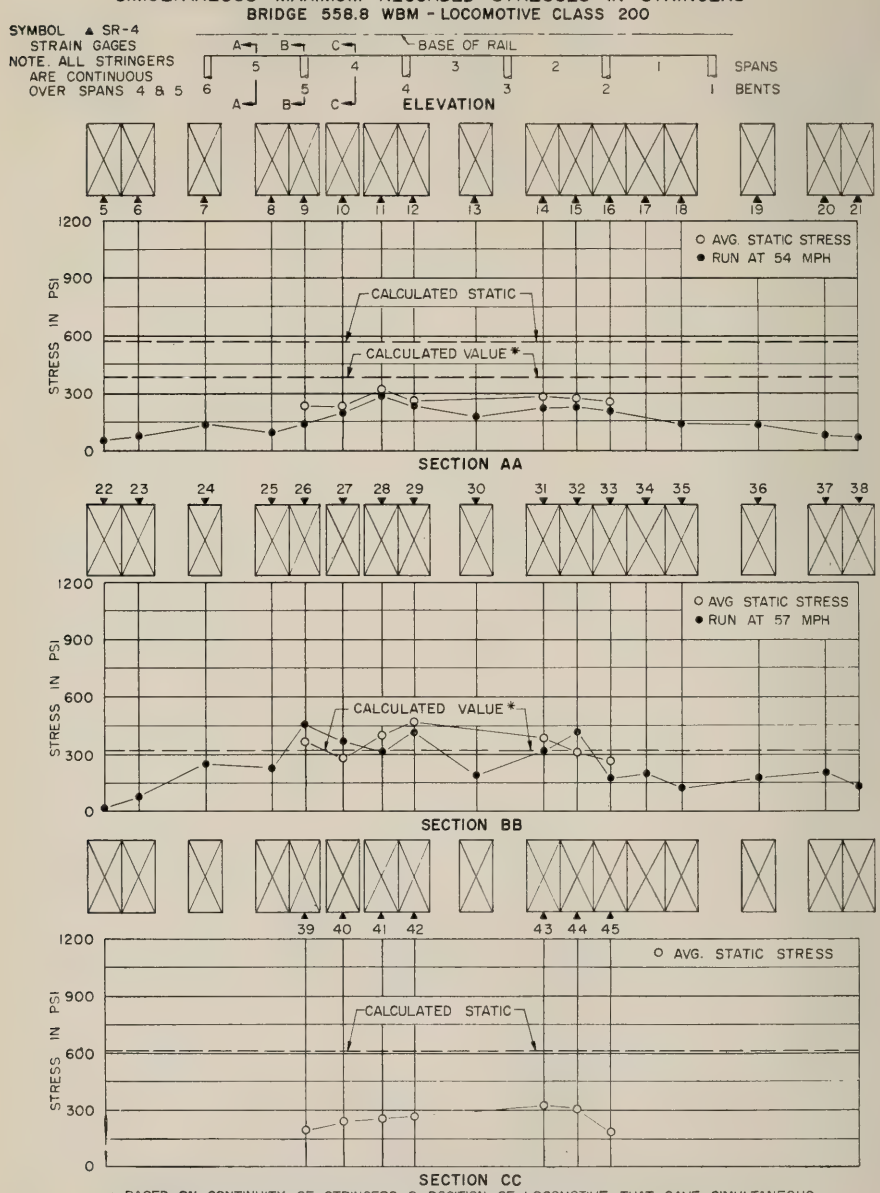


FIG 7
SANTA FE TIMBER TRESTLE TESTS
SIMULTANEOUS MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 558.8 EBM - LOCOMOTIVE CLASS 200
SYMBOLS
▲ SR-4 STRAIN GAGES
C CONTINUOUS OVER SPANS 4 & 5
BASE OF RAIL
SPANS
BENTS
ELEVATION
CALCULATED STATIC
CALCULATED VALUE *
O AVG STATIC STRESS
● RUN AT 21 MPH
STRESS IN PSI
SECTION AA
● RUN AT 20 MPH
SECTION BB
SECTION CC
* BASED ON CONTINUITY OF STRINGERS & POSITION OF LOCOMOTIVE THAT GAVE SIMULTANEOUS MAXIMUM RECORDED STRESS ON OSCILLOGRAM

FIG. 8
SANTA FE TIMBER TRESTLE TESTS

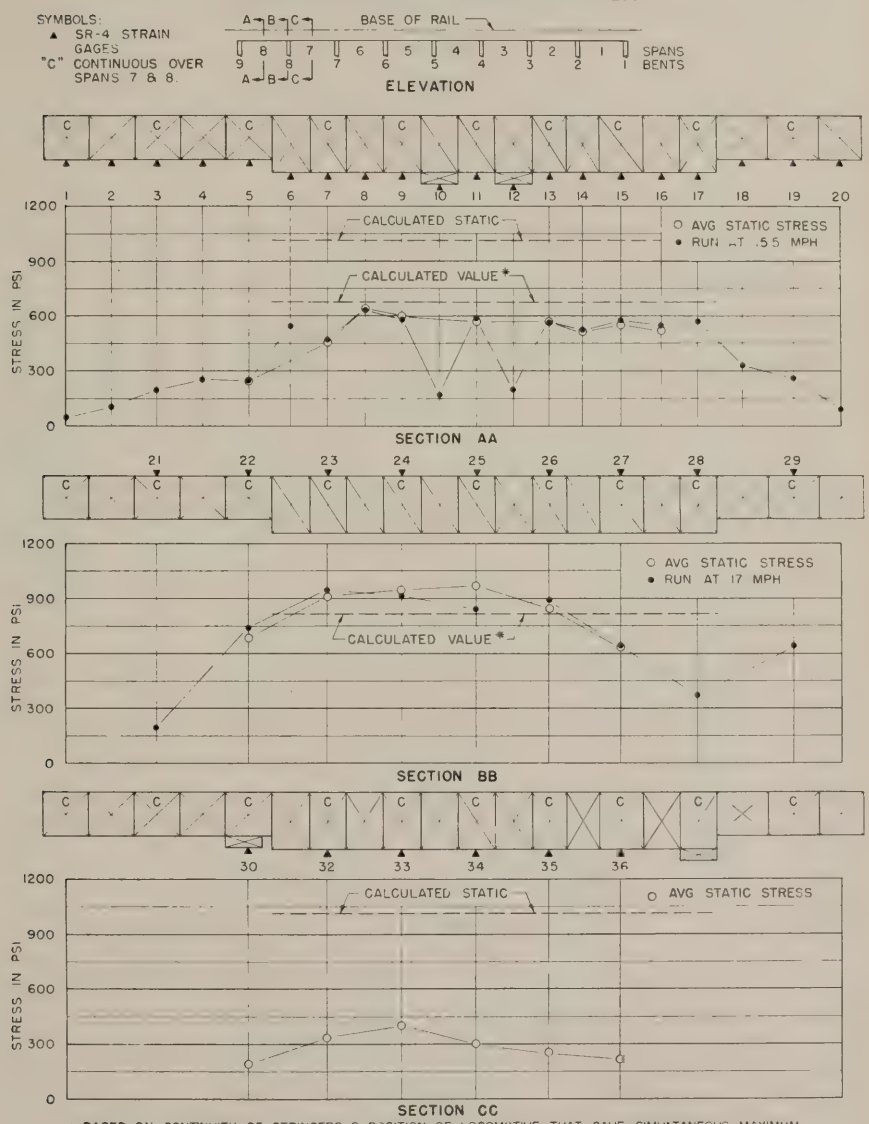
SIMULTANEOUS MAXIMUM RECORDED STRESSES IN STRINGERS

BRIDGE 558.8 WBM - LOCOMOTIVE CLASS 200



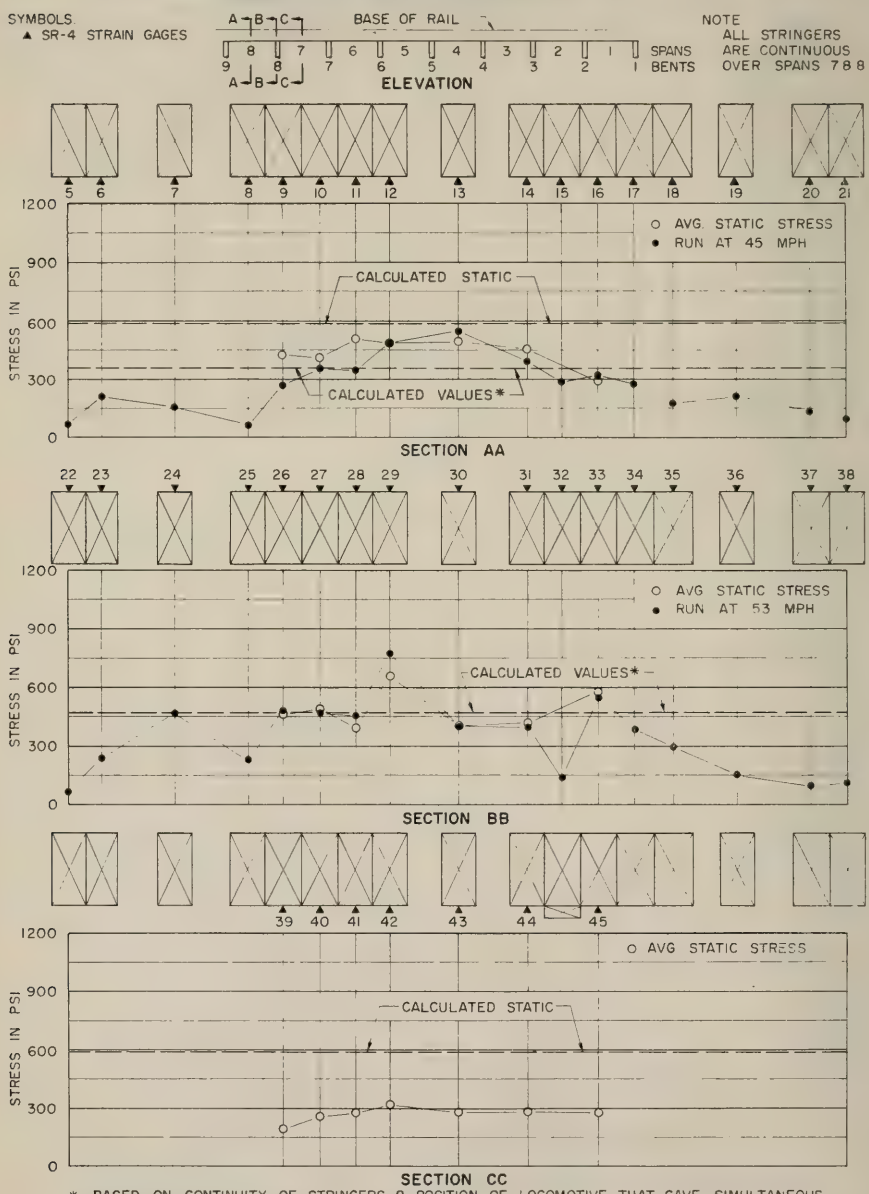
* BASED ON CONTINUITY OF STRINGERS & POSITION OF LOCOMOTIVE THAT GAVE SIMULTANEOUS MAXIMUM RECORDED STRESS ON OSCILLOGRAM

FIG 9
SANTA FE TIMBER TRESTLE TESTS
SIMULTANEOUS MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 EBM - LOCOMOTIVE CLASS 200



* BASED ON CONTINUITY OF STRINGERS & POSITION OF LOCOMOTIVE THAT GAVE SIMULTANEOUS MAXIMUM RECORDED STRESS ON OSCILLOGRAM

FIG 10
SANTA FE TIMBER TRESTLE TESTS
SIMULTANEOUS MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 WBM - LOCOMOTIVE CLASS 200



* BASED ON CONTINUITY OF STRINGERS & POSITION OF LOCOMOTIVE THAT GAVE SIMULTANEOUS MAXIMUM RECORDED STRESS ON OSCILLOGRAM

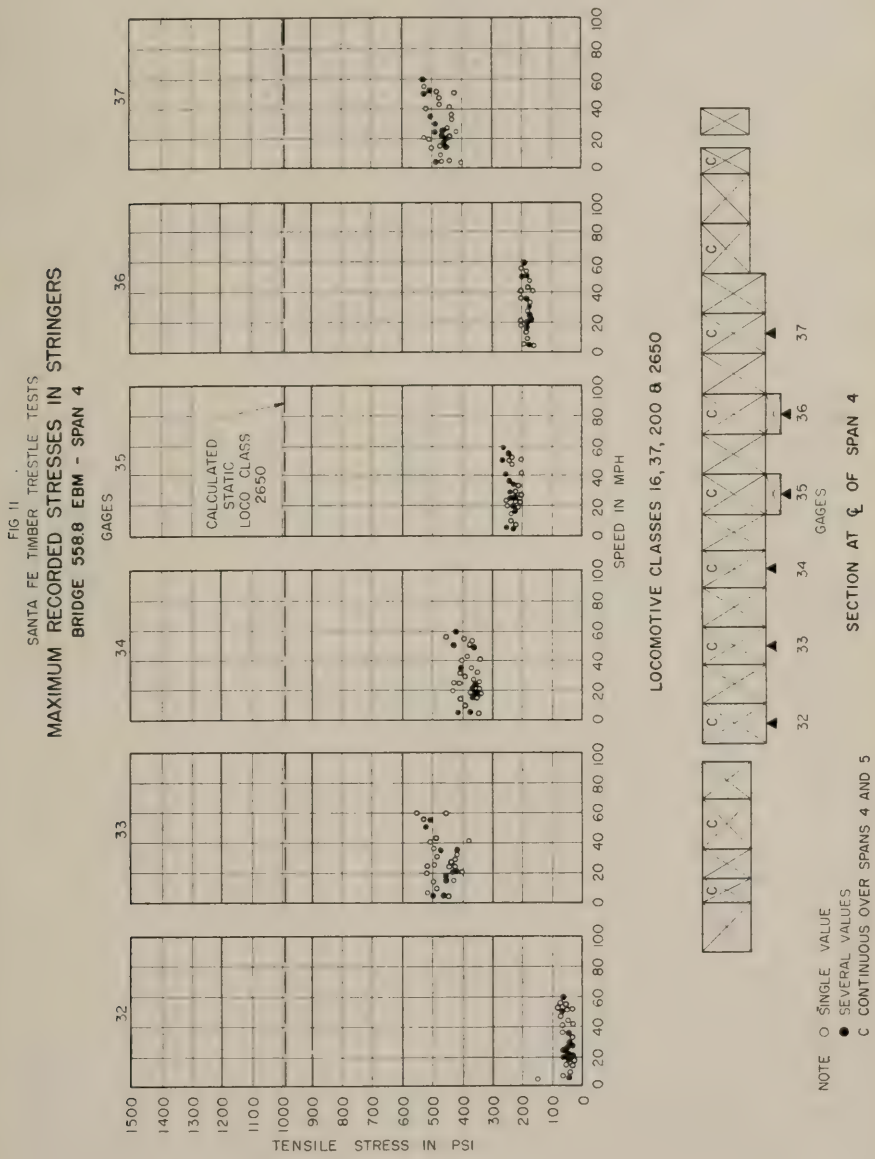


FIG 11
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 558.8 EBM - SPAN 4
GAGES
32
33
34
35
36
37
CALCULATED STATIC LOCO CLASS 2650
TENSILE STRESS IN PSI
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 200 & 2650
SECTION AT ℄ OF SPAN 4
NOTE ○ SINGLE VALUE
● SEVERAL VALUES
C CONTINUOUS OVER SPANS 4 AND 5

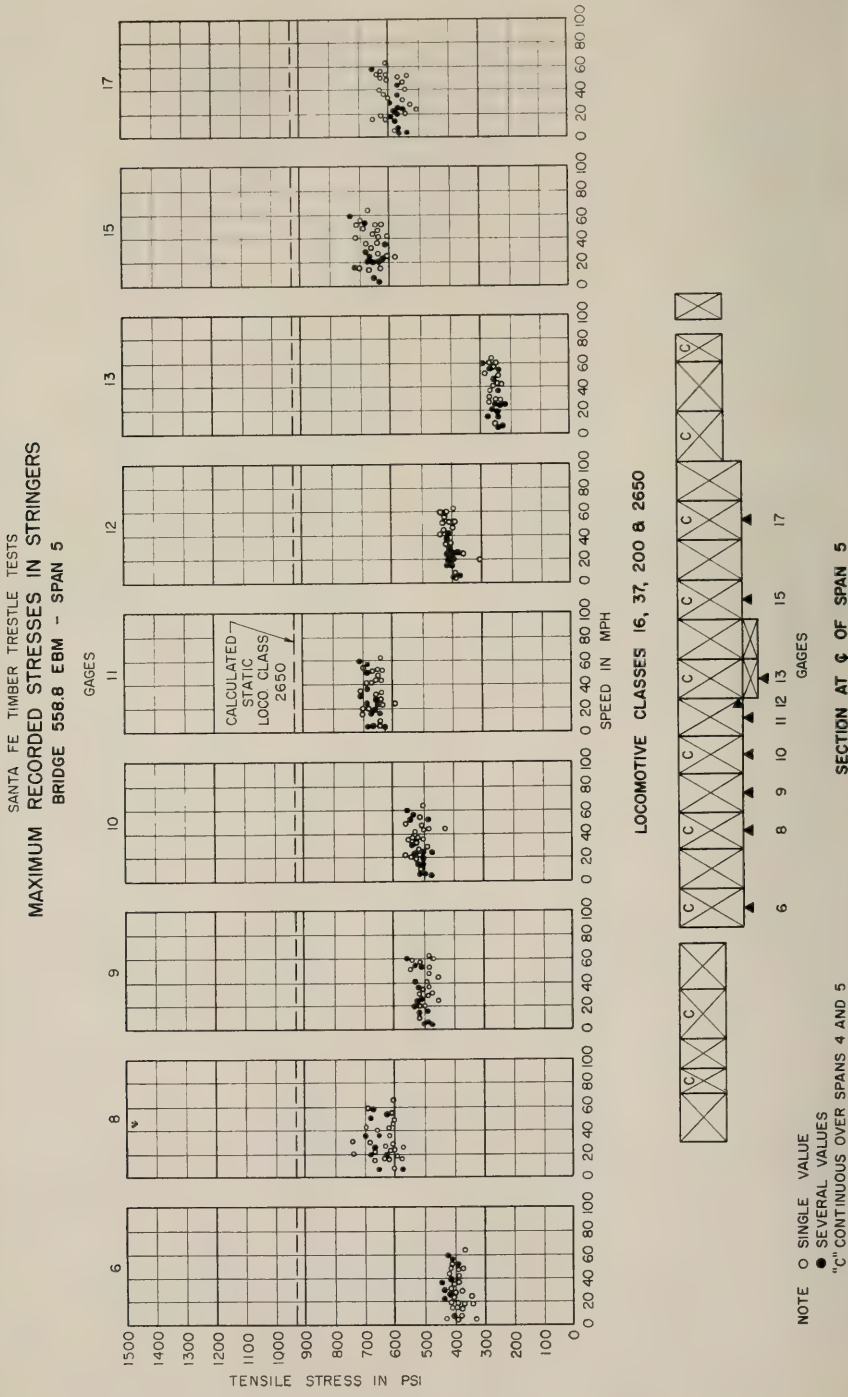


FIG 12
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 558.8 EBM - SPAN 5
GAGES
6
8
9
10
11
12
13
15
17
CALCULATED STATIC LOCO CLASS 2650
TENSILE STRESS IN PSI
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0 20 40 60 80 100
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 200 & 2650
C
6 8 9 10 11 12 13 15 17
GAGES
SECTION AT ℄ OF SPAN 5
NOTE ○ SINGLE VALUE
● SEVERAL VALUES
"C" CONTINUOUS OVER SPANS 4 AND 5

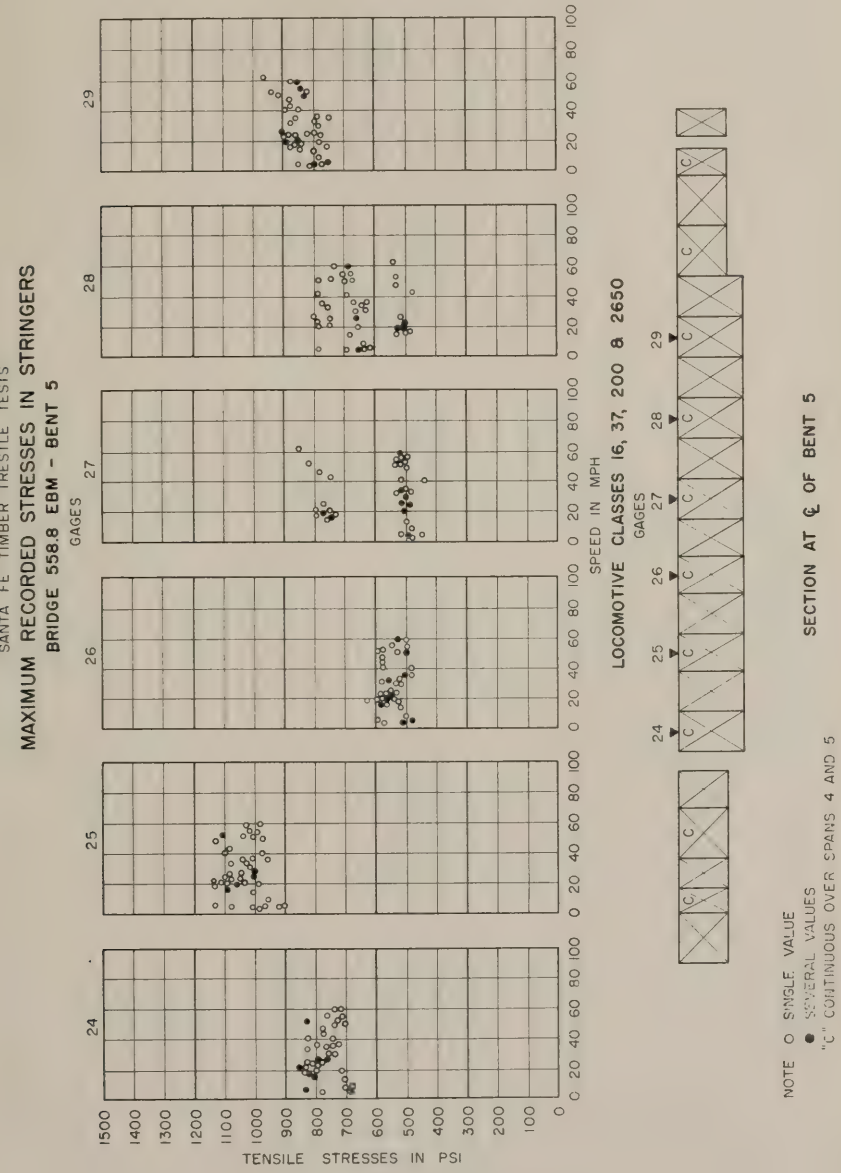


FIG 13
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 558.8 EBM - BENT 5
GAGES
24
25
26
27
28
29
TENSILE STRESSES IN PSI
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
SPEED IN MPH
0 20 40 60 80 100
LOCOMOTIVE CLASSES 16, 37, 200 & 2650
SECTION AT ℄ OF BENT 5
C
NOTE ○ SINGLE VALUE
● SEVERAL VALUES
"C" CONTINUOUS OVER SPANS 4 AND 5

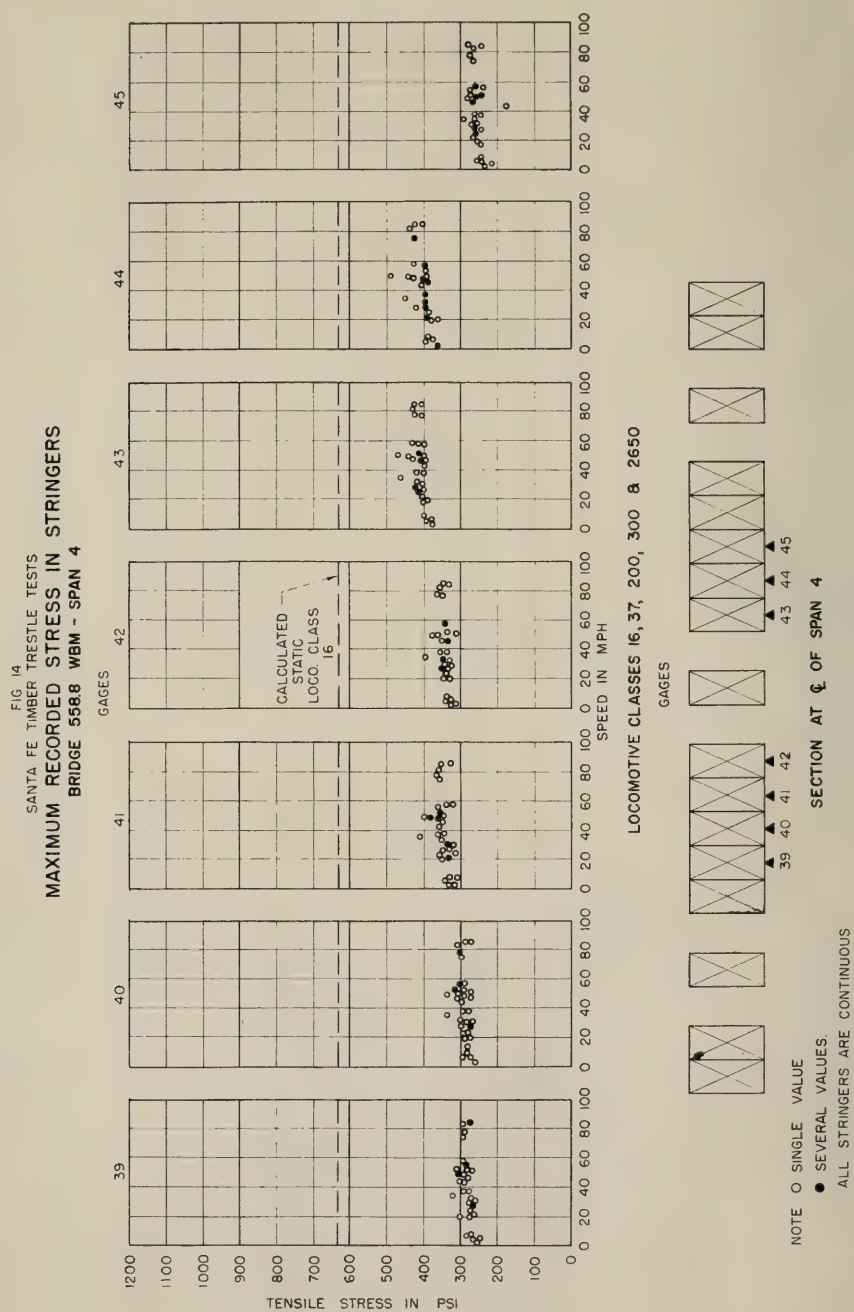


FIG 14
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESS IN STRINGERS
BRIDGE 558.8 WBM - SPAN 4
GAGES
39
40
41
42
43
44
45
CALCULATED STATIC LOCO. CLASS 16
TENSILE STRESS IN PSI
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 200, 300 & 2650
GAGES
39 40 41 42
43 44 45
SECTION AT ℄ OF SPAN 4
NOTE O SINGLE VALUE
● SEVERAL VALUES.
ALL STRINGERS ARE CONTINUOUS OVER SPANS 4 AND 5

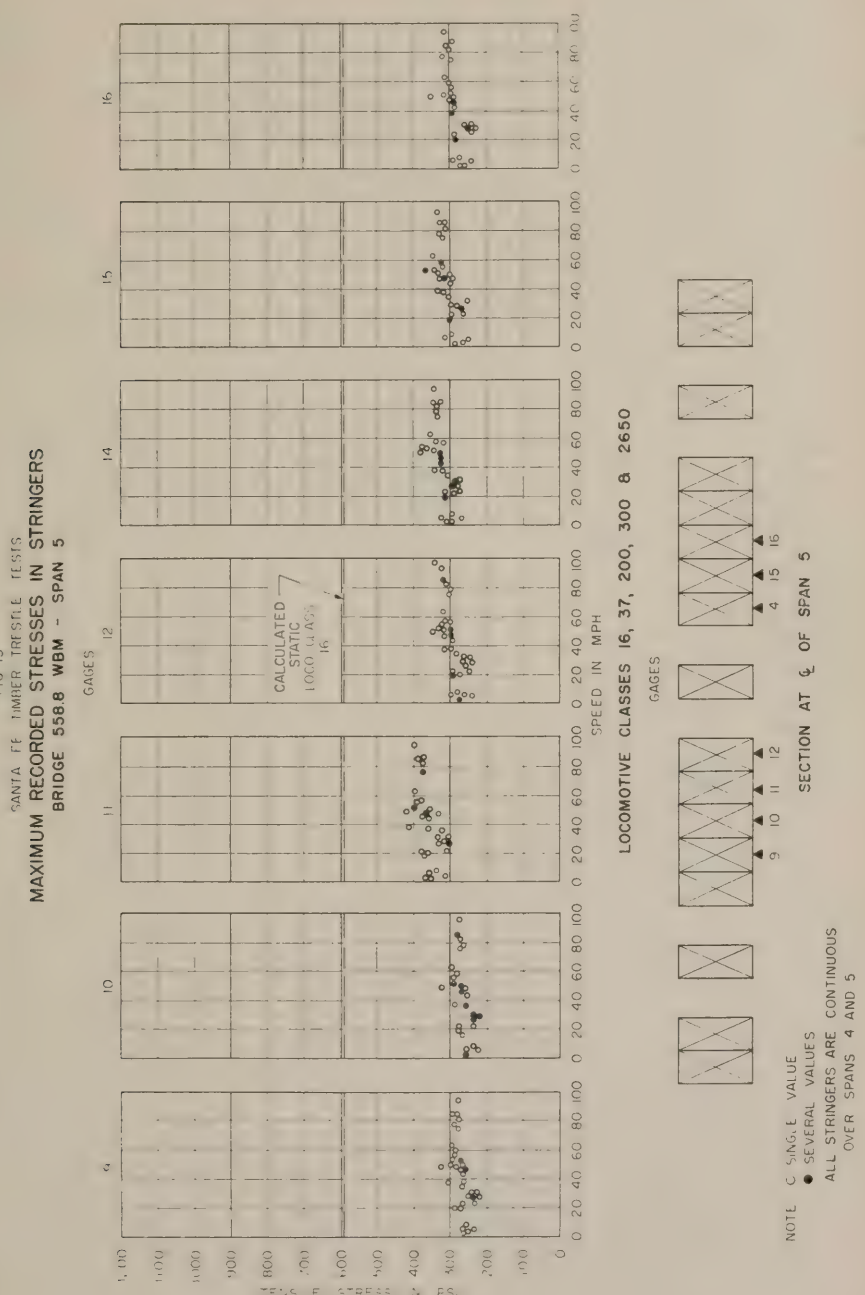


FIG 15
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 558.8 WBM - SPAN 5
GAGES
9
10
11
12
14
15
16
CALCULATED STATIC LOCO CLASS 16
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 200, 300 & 2650
GAGES
9 10 11 12
4 15 16
SECTION AT ℄ OF SPAN 5
NOTE ○ SINGLE VALUE
● SEVERAL VALUES
ALL STRINGERS ARE CONTINUOUS OVER SPANS 4 AND 5

A

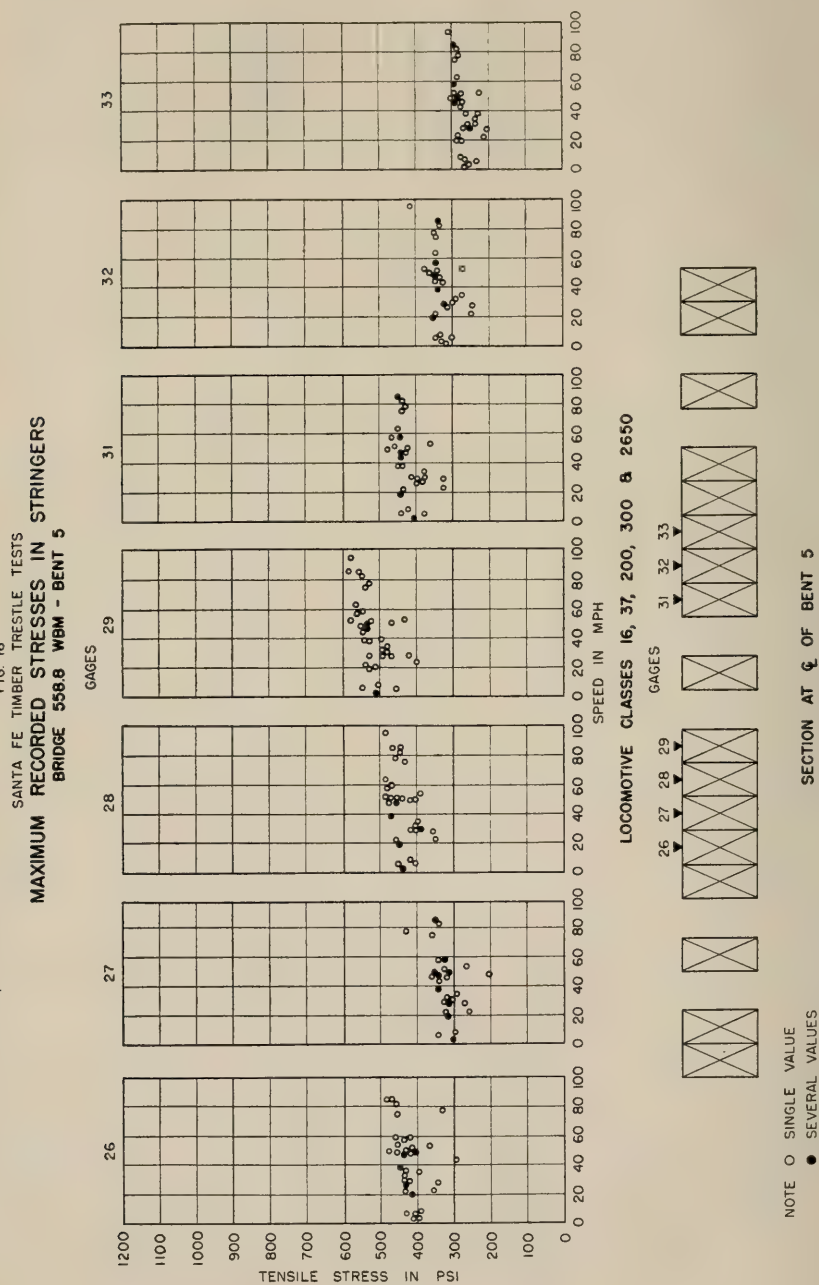


FIG. 16
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 558.8 WBM - BENT 5
GAGES
26
27
28
29
31
32
33
TENSILE STRESS IN PSI
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
SPEED IN MPH
0 20 40 60 80 100
LOCOMOTIVE CLASSES 16, 37, 200, 300 & 2650
GAGES
26 27 28 29
31 32 33
SECTION AT ℄ OF BENT 5
NOTE O SINGLE VALUE
● SEVERAL VALUES
ALL STRINGERS ARE CONTINUOUS
OVER SPANS 4 AND 5

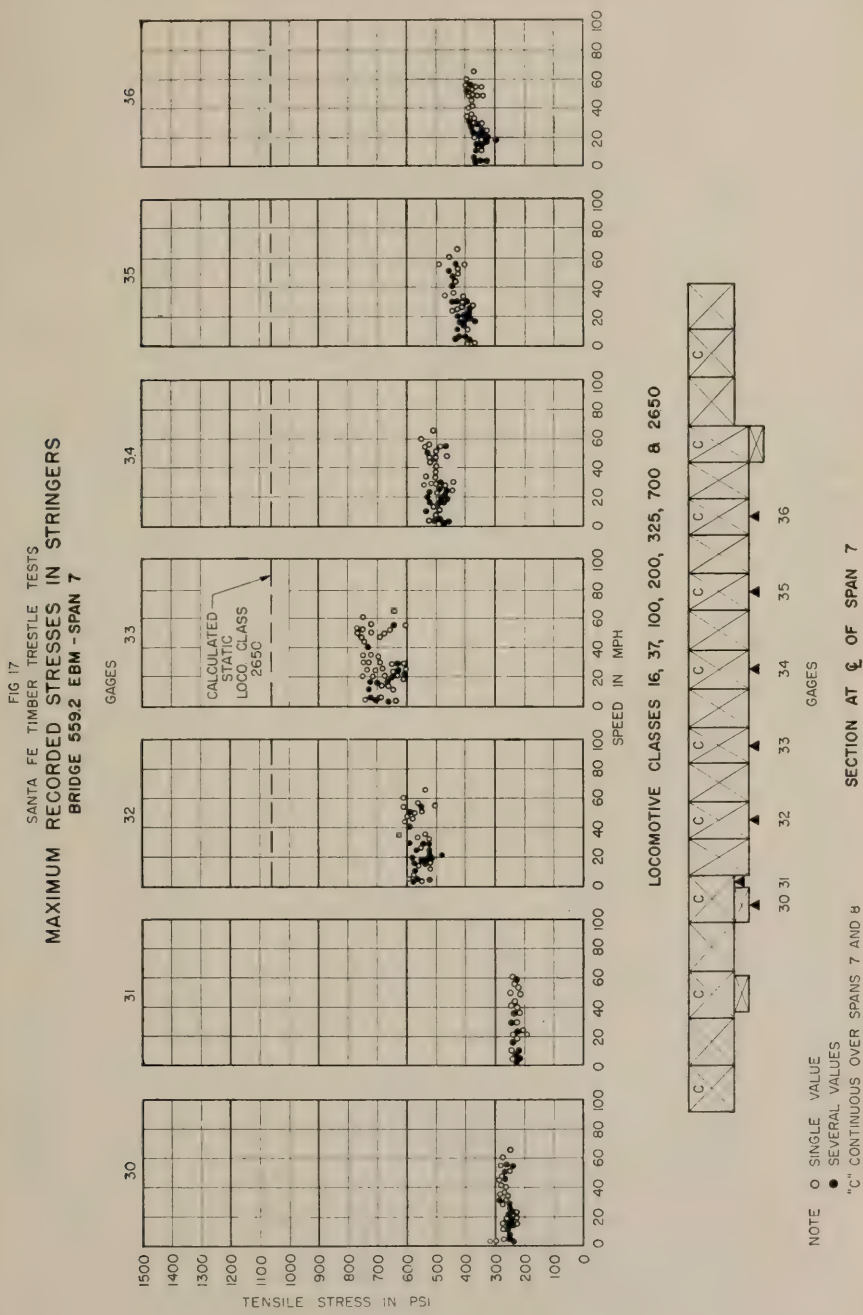


FIG 17
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 EBM - SPAN 7
GAGES
30
31
32
33
34
35
36
CALCULATED STATIC LOCO. CLASS 2650
TENSILE STRESS IN PSI
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 100, 200, 325, 700 & 2650
SECTION AT ℄ OF SPAN 7
NOTE O SINGLE VALUE
● SEVERAL VALUES
"C" CONTINUOUS OVER SPANS 7 AND 8

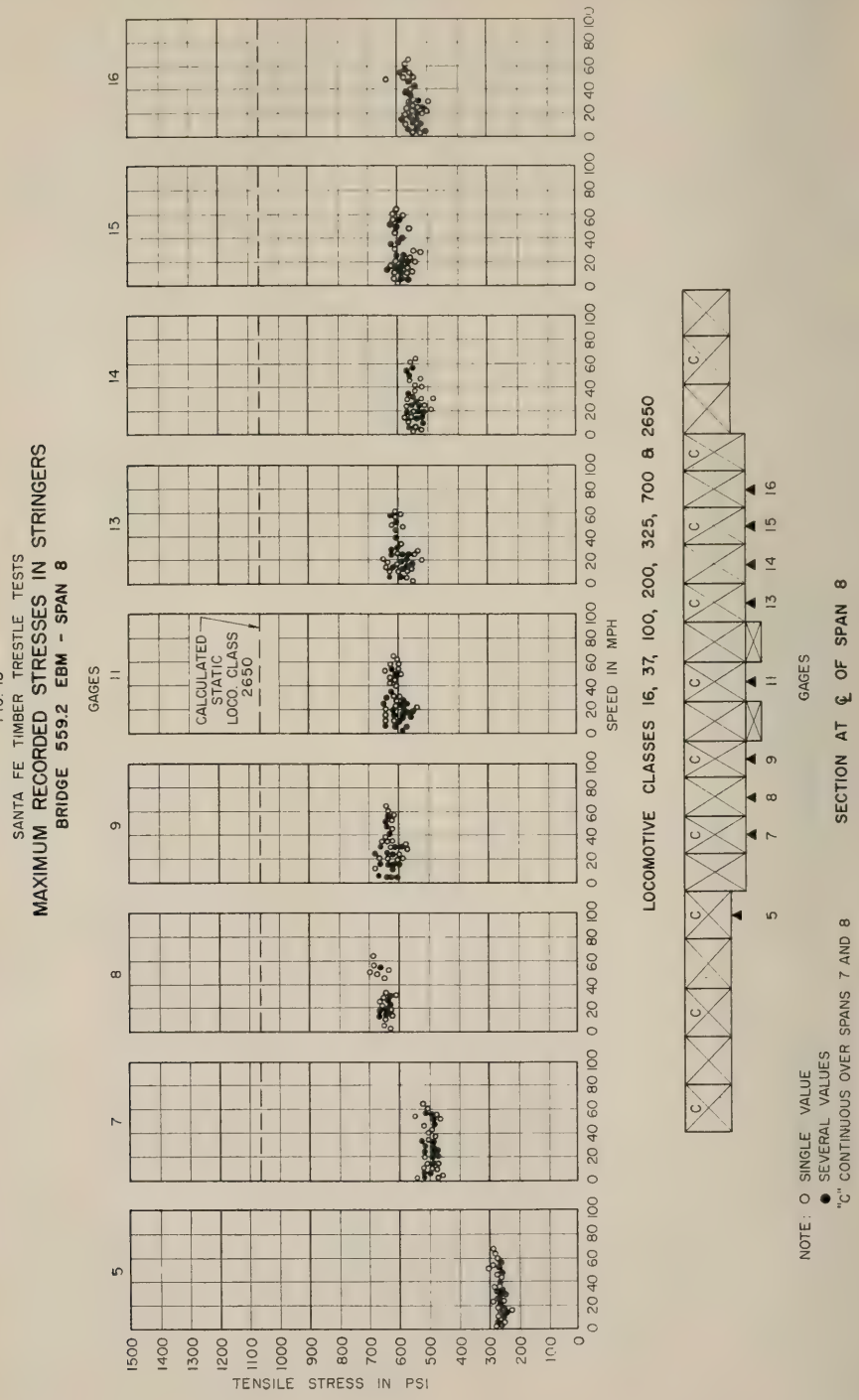


FIG. 18
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 EBM - SPAN 8
GAGES
5
7
8
9
11
13
14
15
16
CALCULATED STATIC LOCO. CLASS 2650
TENSILE STRESS IN PSI
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0 20 40 60 80 100
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 100, 200, 325, 700 & 2650
C
5
7
8
9
11
13
14
15
16
GAGES
SECTION AT ℄ OF SPAN 8
NOTE: O SINGLE VALUE
● SEVERAL VALUES
"C" CONTINUOUS OVER SPANS 7 AND 8

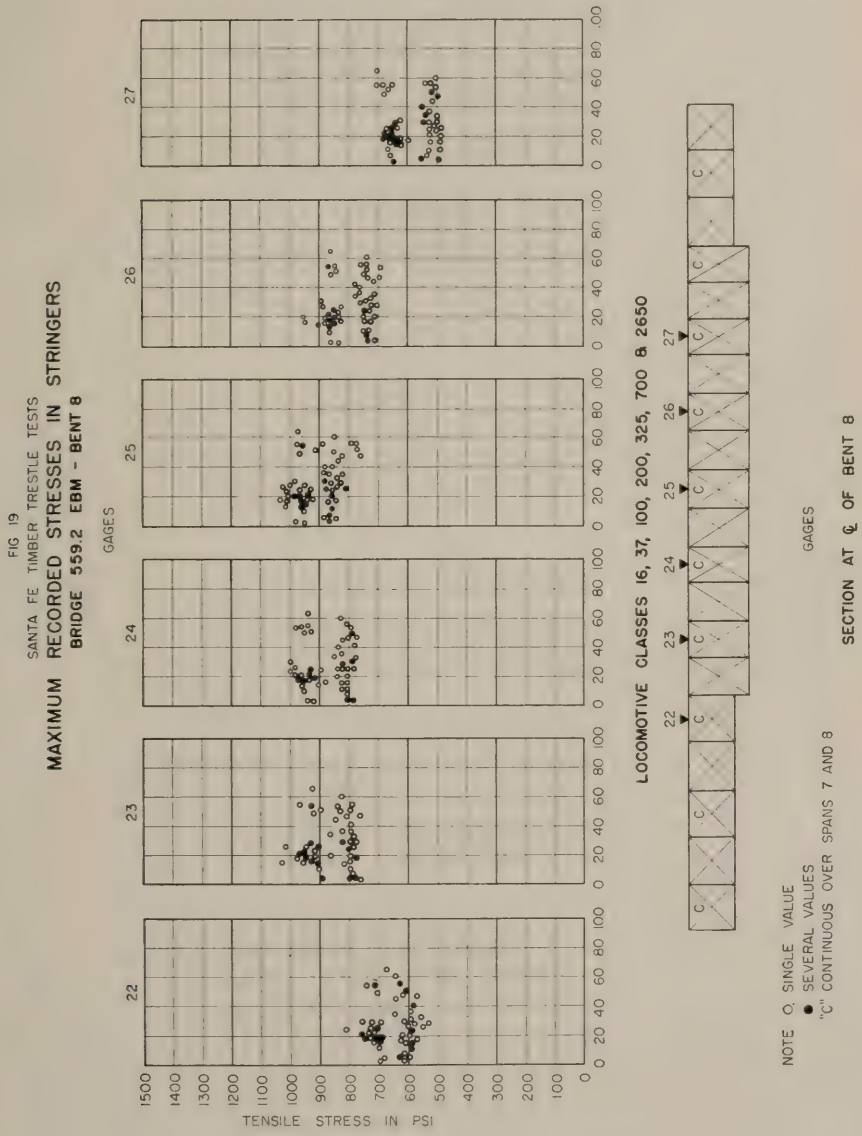


FIG 19
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 EBM - BENT 8
GAGES
22
23
24
25
26
27
TENSILE STRESS IN PSI
LOCOMOTIVE CLASSES 16, 37, 100, 200, 325, 700 & 2650
GAGES
SECTION AT ℄ OF BENT 8
NOTE ○ SINGLE VALUE
● SEVERAL VALUES
"C" CONTINUOUS OVER SPANS 7 AND 8

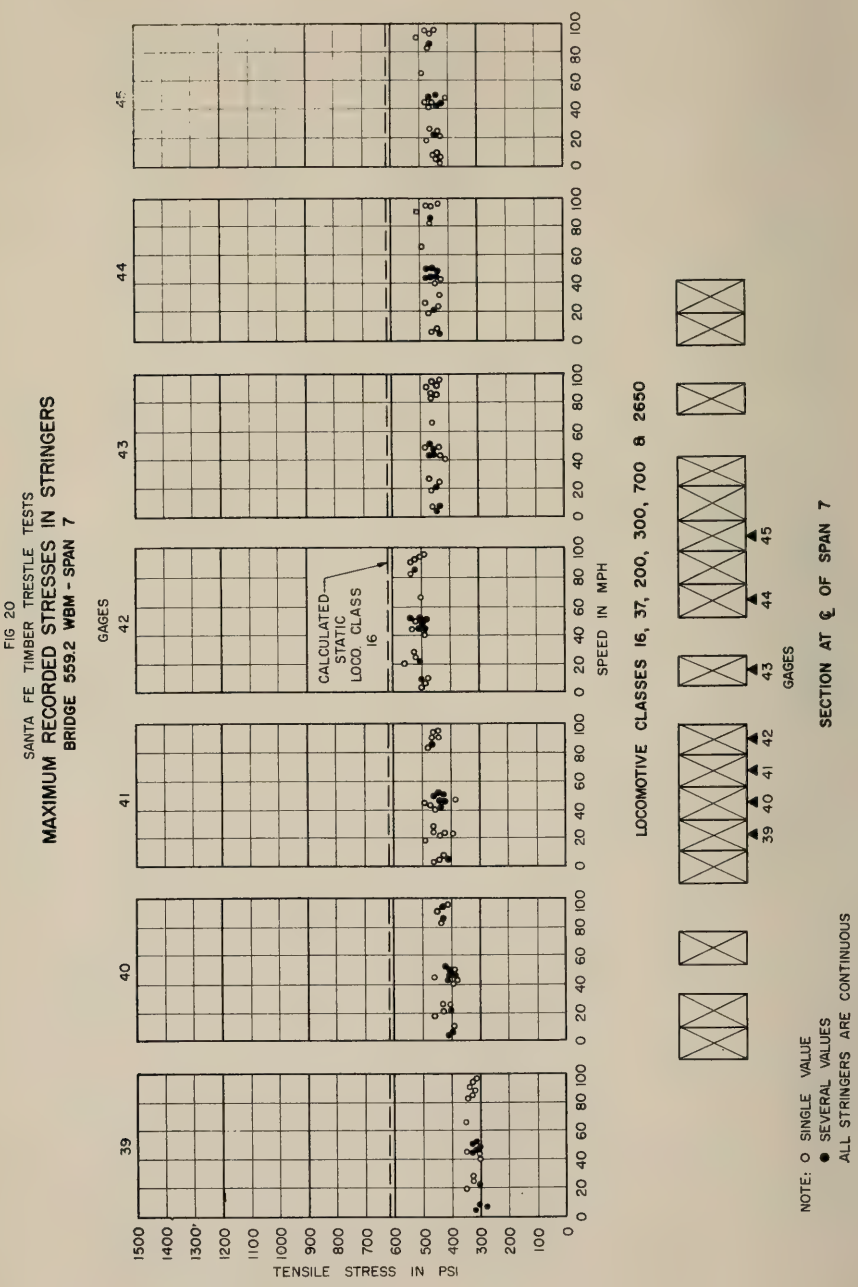


FIG 20
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 WBM - SPAN 7
GAGES
39
40
41
42
43
44
45
CALCULATED STATIC LOCO CLASS 16
TENSILE STRESS IN PSI
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0 20 40 60 80 100
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 200, 300, 700 & 2650
39 40 41 42 43 44 45
GAGES
SECTION AT ℄ OF SPAN 7
NOTE: O SINGLE VALUE
● SEVERAL VALUES
ALL STRINGERS ARE CONTINUOUS
OVER SPANS 7 AND 8

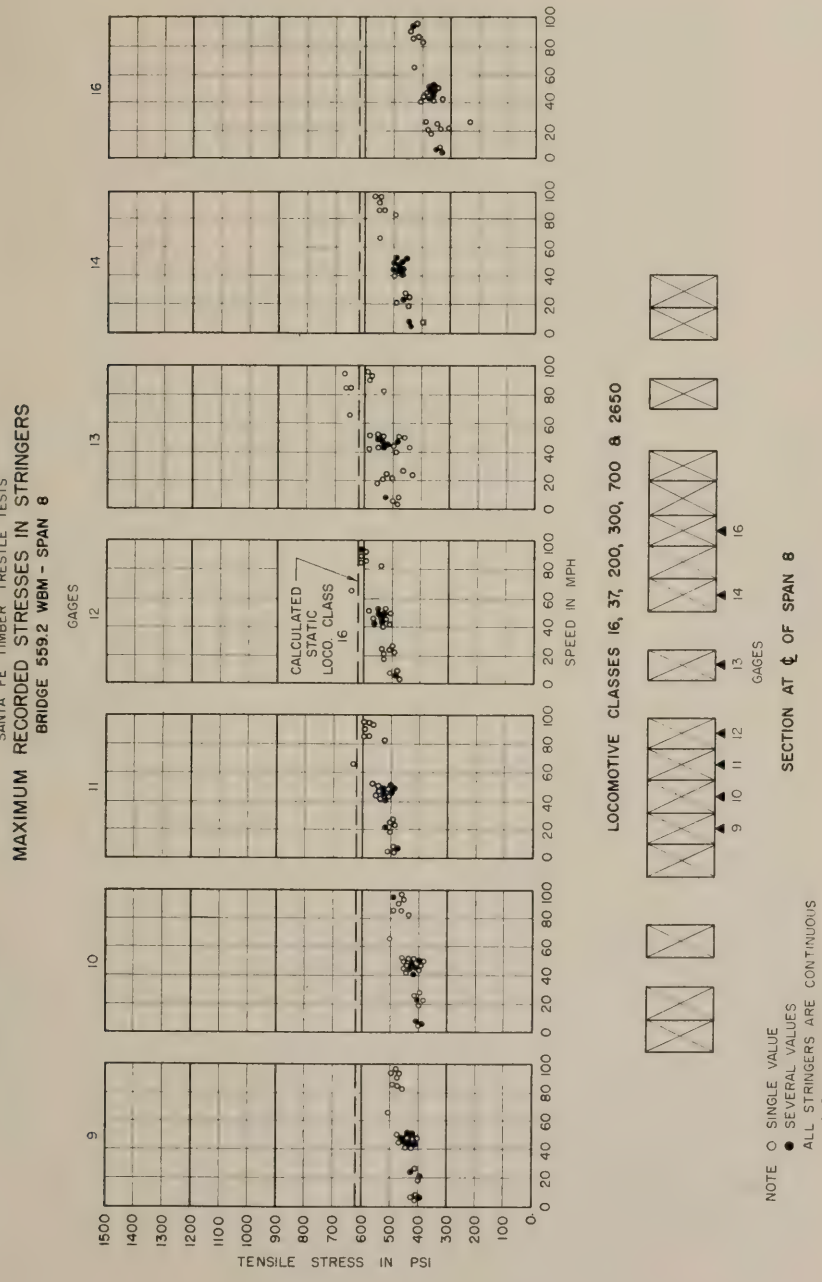


FIG 21
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 WBM - SPAN 8
GAGES
9
10
11
12
13
14
16
CALCULATED STATIC LOCO. CLASS 16
TENSILE STRESS IN PSI
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0 20 40 60 80 100
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 200, 300, 700 & 2650
9 10 11 12
13
14
16
GAGES
SECTION AT ℄ OF SPAN 8
NOTE ○ SINGLE VALUE
● SEVERAL VALUES
ALL STRINGERS ARE CONTINUOUS
OVER SPANS 7 AND 8

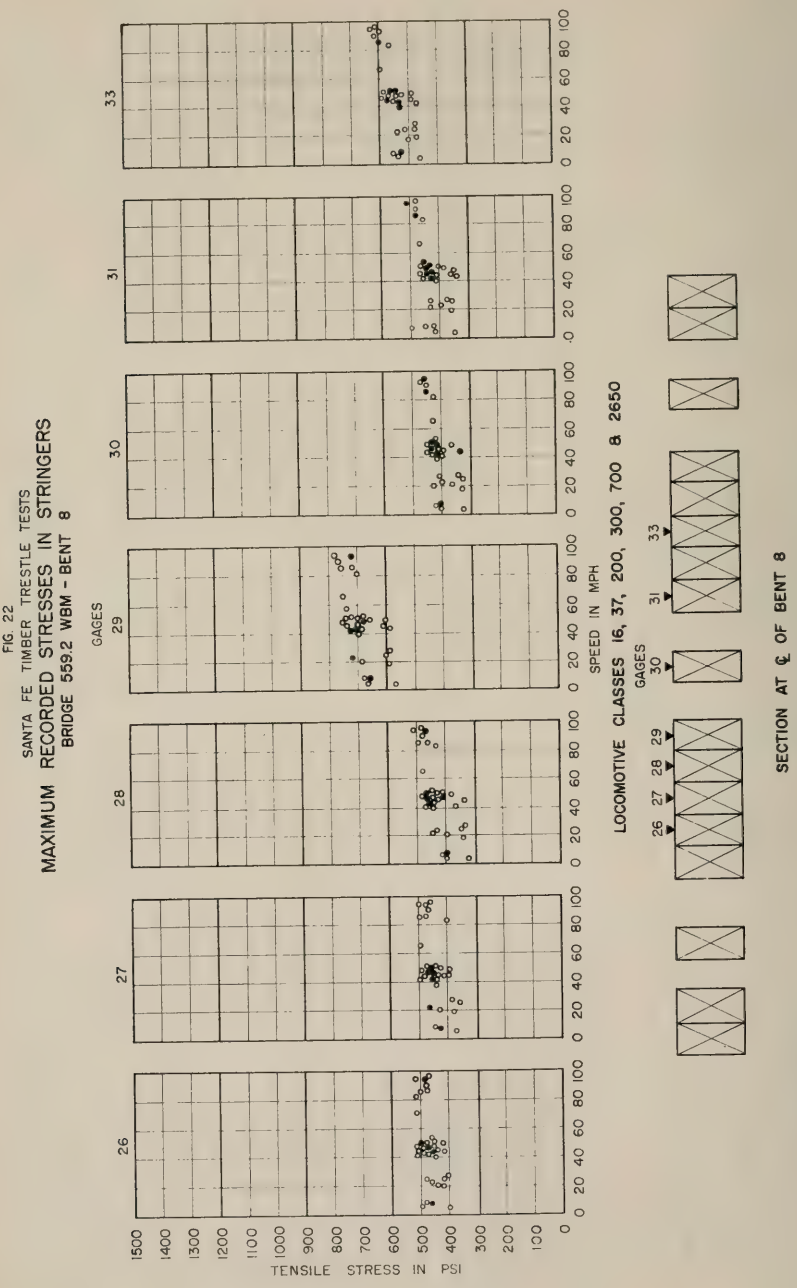
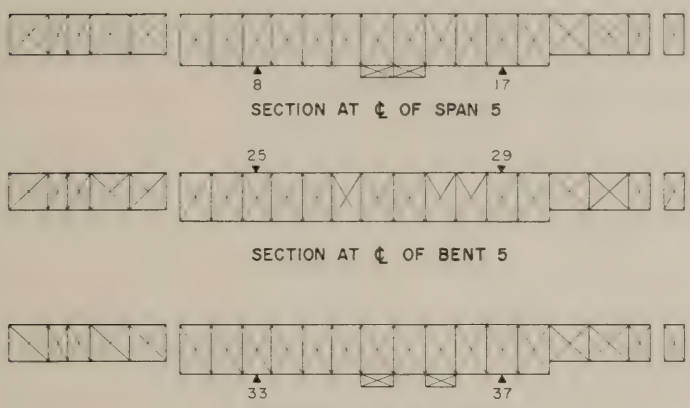
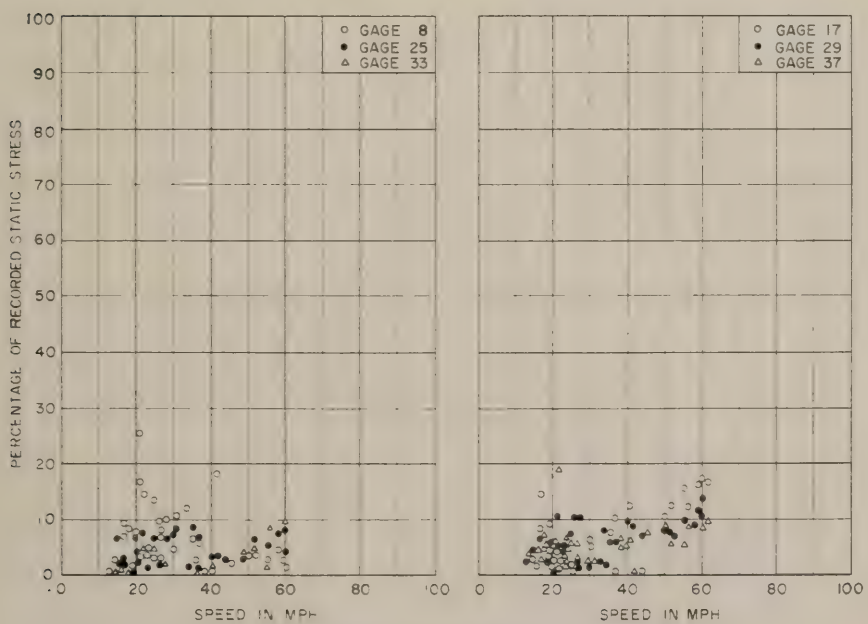


FIG. 22
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN STRINGERS
BRIDGE 559.2 WBM - BENT 8
GAGES
26
27
28
29
30
31
33
TENSILE STRESS IN PSI
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0 20 40 60 80 100
SPEED IN MPH
LOCOMOTIVE CLASSES 16, 37, 200, 300, 700 & 2650
GAGES
26 27 28 29
30
31
33
SECTION AT ℄ OF BENT 8
NOTE: O SINGLE VALUE
● SEVERAL VALUES
ALL STRINGERS ARE CONTINUOUS
OVER SPANS 7 AND 8

FIG. 23
SANTA FE TIMBER TRESTLE TESTS
RECORDED TOTAL IMPACTS IN STRINGERS
BRIDGE 558.8 EBM

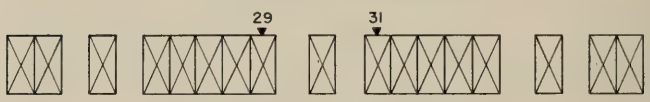




LOCOMOTIVE CLASSES 200 & 2650

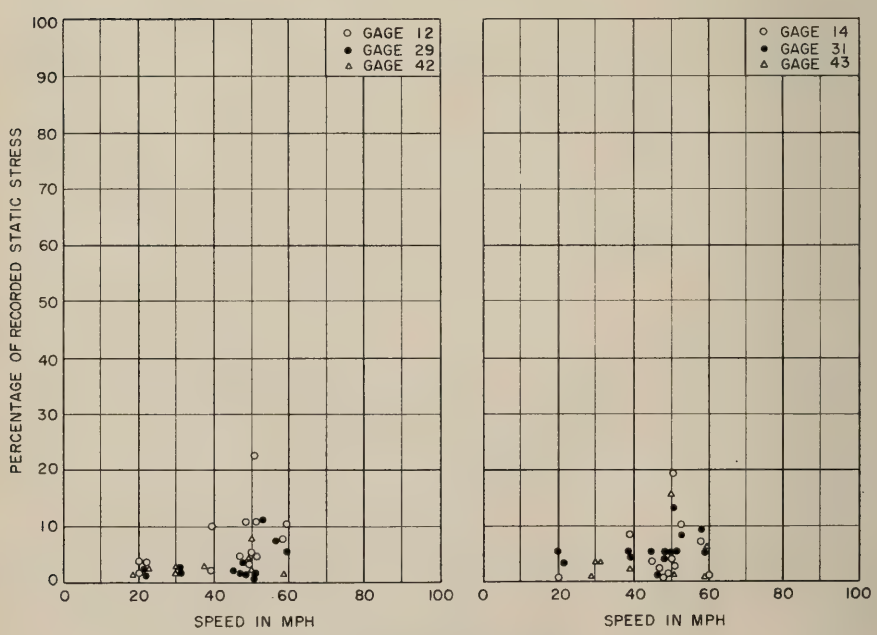
FIG. 24
SANTA FE TIMBER TRESTLE TESTS
RECORDED TOTAL IMPACTS IN STRINGERS
BRIDGE 558.8 WBM

SECTION AT ℄ OF SPAN 5



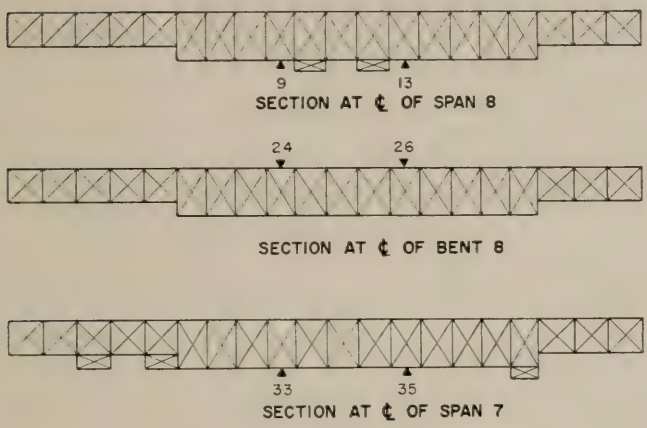
SECTION AT ℄ OF BENT 5

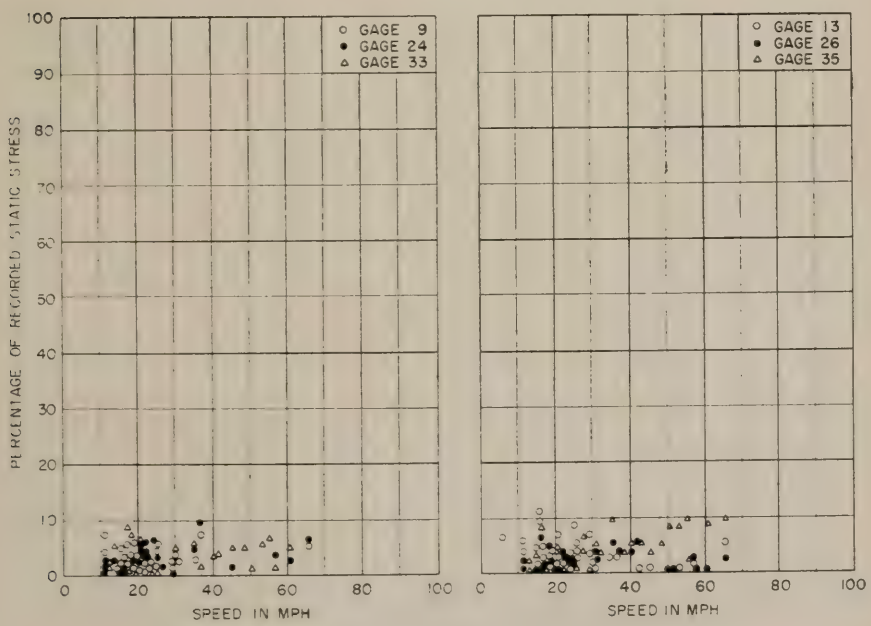
SECTION AT ℄ OF SPAN 4



LOCOMOTIVE CLASS 200

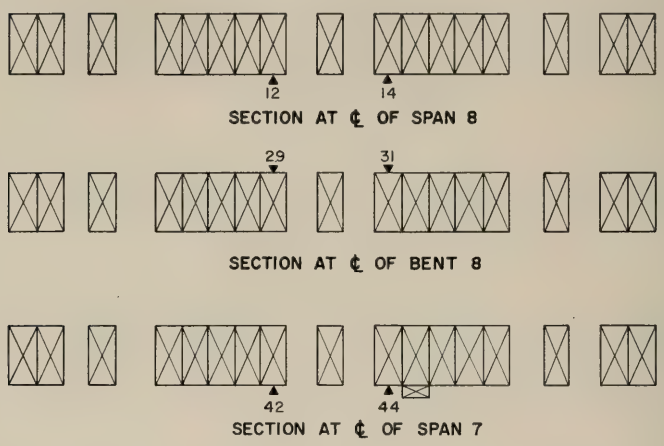
FIG 25
SANTA FE TIMBER TRESTLE TESTS
RECORDED TOTAL IMPACTS IN STRINGERS
BRIDGE 559.2 EBM

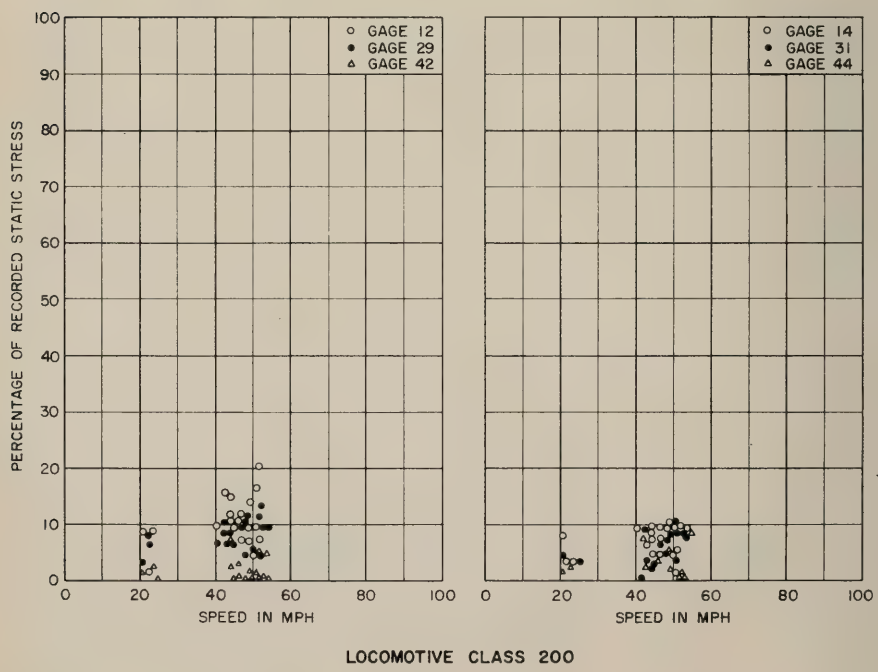




LOCOMOTIVE CLASS 200

FIG. 26
SANTA FE TIMBER TRESTLE TESTS
RECORDED TOTAL IMPACTS IN STRINGERS
BRIDGE 559.2 WBM





LOCOMOTIVE CLASS 200

FIG 27
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN BENTS
BRIDGE 558.8 WBM
LOCOMOTIVE CLASS 2650

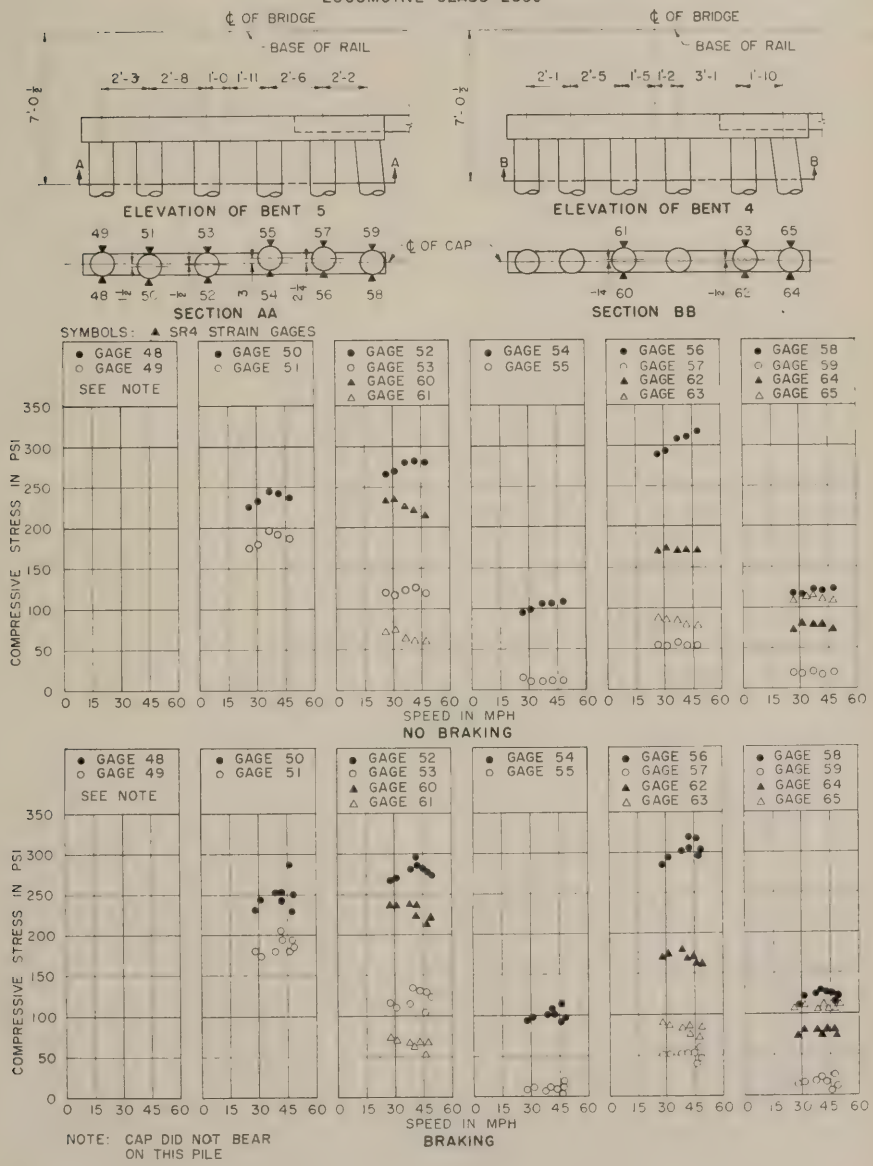


FIG. 28
SANTA FE TIMBER TRESTLE TESTS
MAXIMUM RECORDED STRESSES IN BENTS
BRIDGE 559.2 WBM
LOCOMOTIVE CLASS 2650

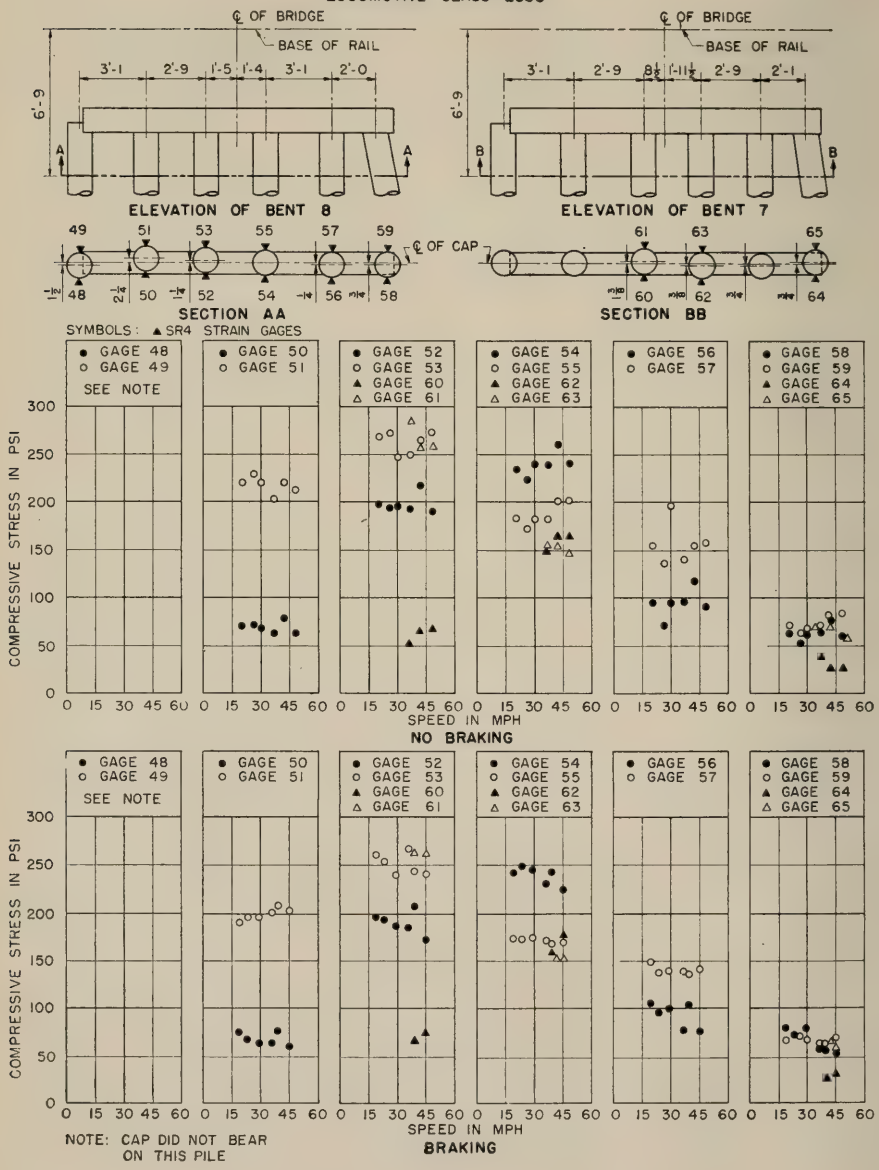


FIG 29
SANTA FE TIMBER TRESTLE TESTS
RECORDED DEFLECTION AT ℄ OF SPAN
BRIDGE 558.8

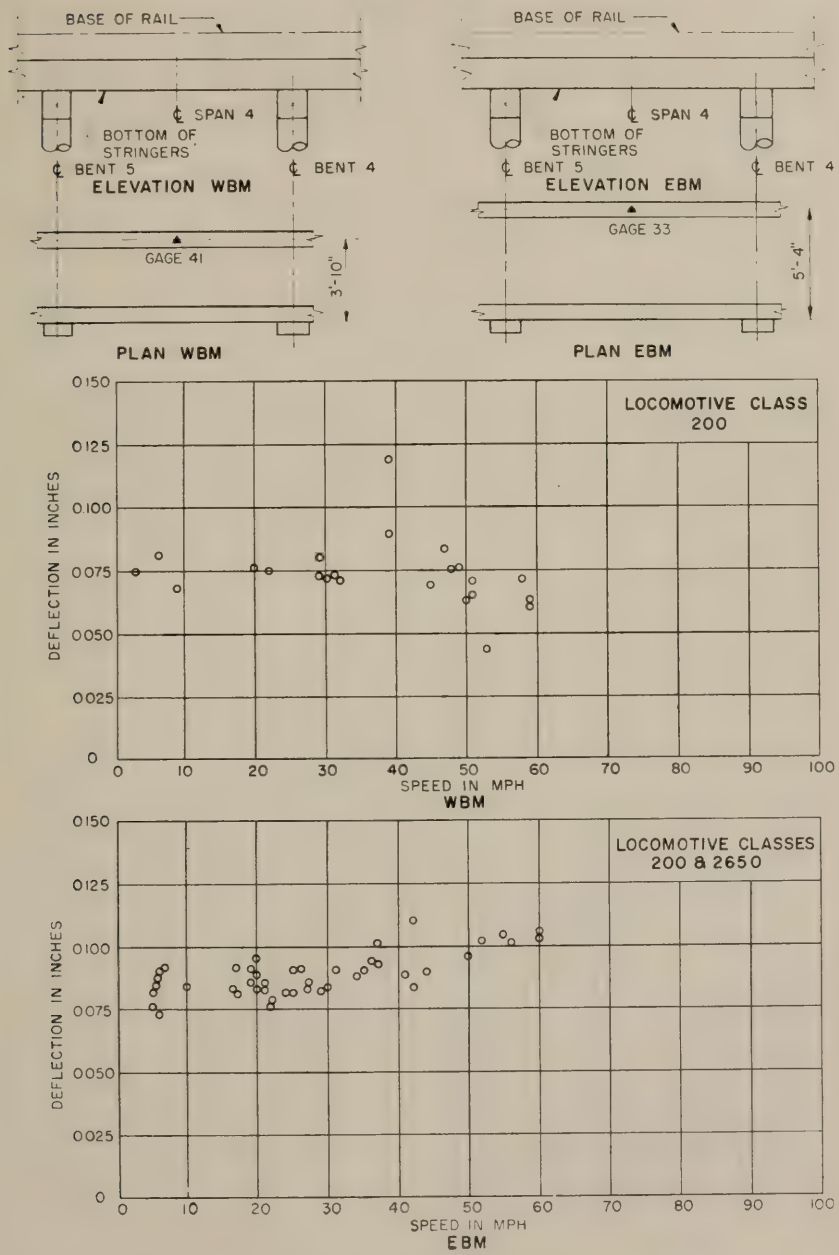
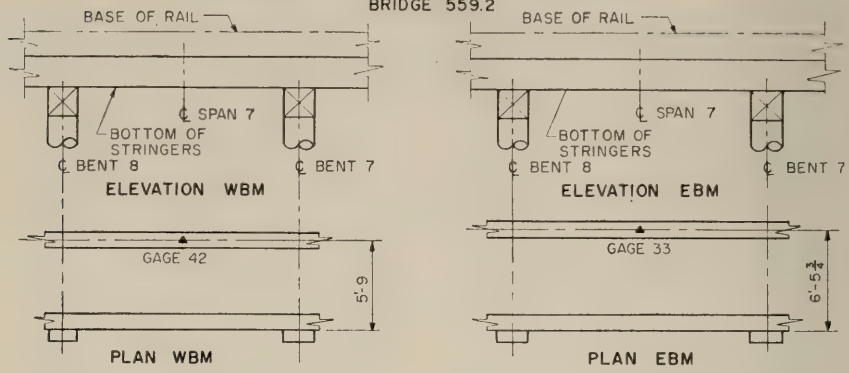
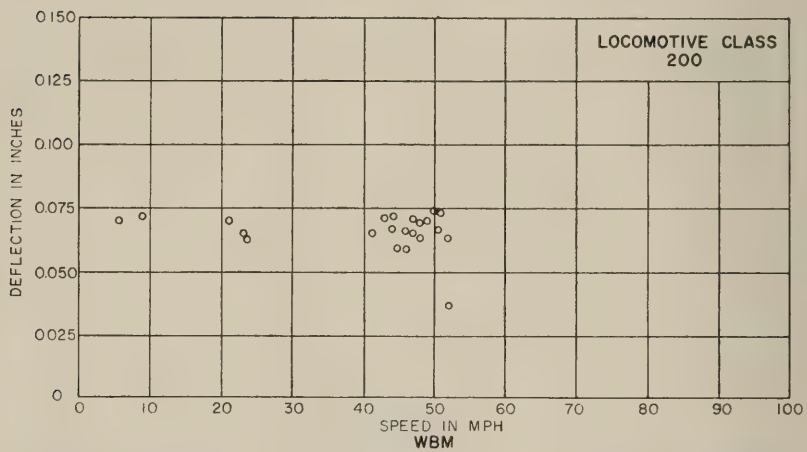


FIG 30
SANTA FE TIMBER TRESTLE TESTS
RECORDED DEFLECTION AT ℄ OF SPAN
BRIDGE 559.2





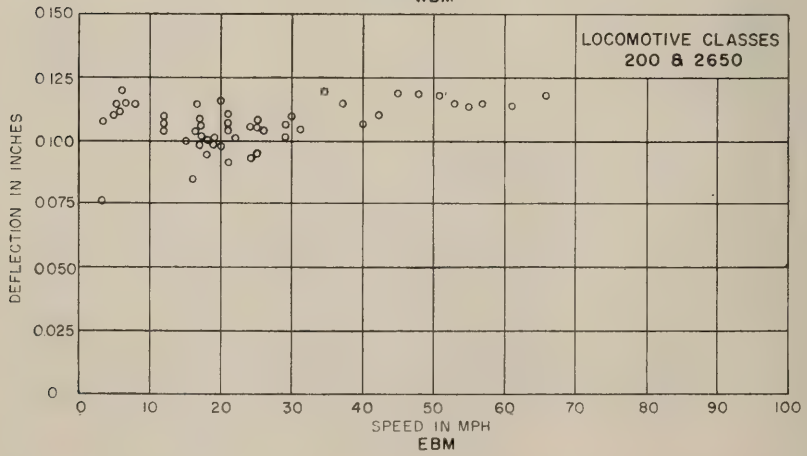
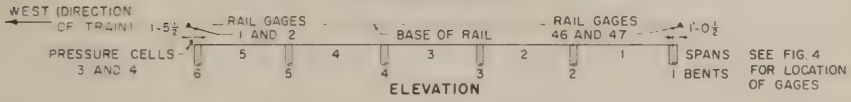


FIG 31

SANTA FE TIMBER TRESTLE TESTS

RECORDED STRESS VALUES FROM VERTICAL LOADS AND BRAKING TO A STOP ON THE BRIDGE

BRIDGE 558.8 WBM



NOTE FOR PILE GAGES ON BENTS 4 AND 5, THE TOP NUMBER INDICATES THE RECORDED STRESS VALUE FROM VERTICAL LOADS AND THE BOTTOM NUMBER INDICATES THE RECORDED STRESS VALUE FROM BRAKING TO A STOP ON THE BRIDGE

RUN NO	STRESSES FROM VERTICAL LOADS IN PSI AND STRESSES FROM BRAKING TO A STOP ON THE BRIDGE IN PSI																STRESSES FROM BRAKING TO A STOP ON THE BRIDGE IN PSI						
	GAGES ON BENT 5										GAGES ON BENT 4						RAIL GAGES				PRESSURE CELLS		*DIST FT
	59	58	57	56	55	54	53	52	51	50	65	64	63	62	61	60	1	2	46	47	3	4	
115	-21 +26	-123 -38	-48 +16	-281 -48	-13 +13	-104 -45	-104 +30	-266 -42	-173 +26	-248 -60	-106 +23	-76 -18	-77 +46	-157 -30	-52 +28	-200 -26	-1020	-1150	+1020	+980	-0.25	-0.48	-38'-2
116	— +13	— -13	— +12	— -18	— +7	— -10	— +10	— -11	— +12	— -18	— —	— —	— —	— —	— —	— —	—	—	—	—	—	—	+43'-0
117	-89 +32	-116 -35	-38 +25	-266 -18	-105 +27	-97 -46	-83 +40	-256 -41	-146 +42	-239 -65	-113 +21	-85 -18	-72 +32	-164 -25	-55 +22	-202 -23	-980	-840	+1190	+1140	-0.14	-0.30	+45'-11
118	— +22	— -23	— +6	— -27	— +8	— -17	— +17	— -20	— +13	— -30	-81 +11	-76 -25	-42 +20	-151 -33	-32 +15	-197 -37	-780	-790	+710	+730	-0.09	-0.37	+30'-8
119	-7 +28	-116 -38	-35 +21	-277 -16	-5 +31	-102 -30	-87 +30	-258 -33	-148 +26	-242 -38	-108 +26	-81 -16	-67 +46	-163 -25	-51 +33	-198 -23	—	—	+710	+780	-0.14	-0.46	-8'-3
120	— +12	— -13	— +7	— -16	— +10	— -8	— +10	— -11	— +13	— -16	— +11	— -8	— +13	— -11	— +10	— -12	-590	-490	+0	+210	-0	-0.25	+45'-7
121	-20 +35	-121 -40	-48 +25	-280 -26	-13 +21	-97 -47	-94 +41	-256 -42	-154 +31	-238 -69	-108 +21	-80 -21	-75 +54	-163 -33	-55 +32	-202 -30	-1070	-1190	—	—	-0.26	-0.40	-36'-0
122	-8 +30	-116 -26	-41 +22	-277 -32	-7 +17	-102 -25	-82 +37	-258 -21	-141 +38	-242 -35	-101 +16	-77 -20	-64 +27	-169 -30	-47 +26	-217 -35	-1370	-1300	—	—	-0.26	-0.25	+5'-0
123	— +25	— -16	— +10	— -17	— +8	— -10	— +13	— -12	— +13	— -13	-31 0	-36 -15	-16 +13	-79 -21	-11 +12	-97 -21	-540	-490	+140	+210	-0	-0.25	+36'-1
24	-12 +30	-115 -36	-35 +21	-273 -48	-7 +18	-99 -30	-87 +31	-256 -32	-148 +26	-242 -25	-109 +27	-81 -18	-75 +50	-168 -28	-51 +33	-195 -27	—	—	+810	+990	-0.10	-0.51	-7'-11
125	-10 +25	-116 -31	-30 +26	-27 -32	-7 +17	-97 -32	-89 +17	-257 -17	-144 +18	-243 -38	-104 +27	-80 -15	-67 +50	-172 -22	-51 +33	-207 -21	-590	-700	+490	+640	-0	-0.34	-13'-6
126	+17 +21	-108 -36	-3 +17	-226 -47	+21 +16	-94 -31	-45 +17	-179 -32	-74 +17	-173 -45	-105 +21	-86 -13	-76 +38	-165 -17	-55 +25	-198 -20	-980	-990	+620	+570	-0.05	-0.40	+20'-1
27	+13 +11	-80 -18	-3 +8	-169 -23	+15 +5	-64 -16	-22 +10	-131 -17	-56 +8	-129 -22	-109 +7	-77 -6	-79 +16	-157 -12	-55 +11	-185 -11	-440	-490	+190	+260	-0.02	-0.23	+22'-0
128	— +12	— -16	— +8	— -17	— +7	— -7	— +8	— -11	— +10	— -13	— +8	— -6	— +12	— -8	— +10	— -8	-490	-440	+100	+100	-0	-0.25	+58'-6
129	-106 +26	-119 -21	-47 +17	-276 -23	-13 +13	-100 -22	-92 +31	-261 -17	-148 +31	-247 -31	-108 +21	-82 -25	-75 +35	-164 -33	-52 +40	-200 -37	-1120	-840	+810	+880	-0.18	-0.40	-1'-9
130	+32 +21	-47 -26	+22 +16	-71 -31	+17 +10	-33 -17	+27 +17	-51 -21	+17 +16	-61 -31	-84 +8	-80 -26	-48 +21	-173 -38	-33 +15	-31 -36	-890	-900	+680	+640	-0.02	-0.40	+29'-9
131	0 +33	-119 -23	-33 +25	-280 -30	0 +17	-102 -28	-87 +45	-265 -17	-150 +43	-251 -35	-105 +15	-76 -21	-75 +32	-160 -32	-56 +25	-202 -36	-1560	-1040	+380	+570	-0.42	-0.27	+3'-4
32	-21 +22	-94 -21	-51 +13	-236 -30	-16 +13	-72 -22	-121 +21	-227 -20	-184 +21	-196 -31	-125 +18	-66 -18	-113 +33	-135 -25	-84 +22	-184 -25	-880	-490	+710	+670	-0.60	-0.40	-4'-10
133	-21 +26	-101 -26	-48 +20	-241 -45	-18 +13	-74 -37	-121 +30	-232 -36	-162 +26	-197 -47	-116 +21	-67 -16	-96 +36	-140 -21	-70 +22	-185 -17	—	—	—	—	-0.31	-0.29	-42'-3
134	-16 +37	-97 -30	-46 +26	-241 -38	-12 +18	-77 -35	-111 +47	-232 -25	-173 +35	-203 -36	-118 +12	-67 -18	-102 +28	-143 -28	-80 +17	-192 -32	-1320	-1140	+760	+830	-1.07	-0.37	+4'-1

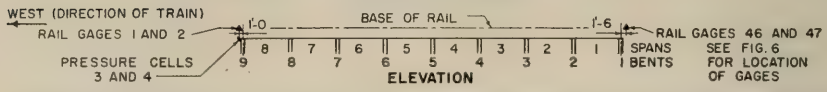
* THE MINUS SIGN INDICATES THE DISTANCE THE TRAIN STOPPED WEST OF THE RAIL GAGES AT WEST END OF BRIDGE AND THE PLUS SIGN INDICATES THE DISTANCE THE TRAIN STOPPED EAST OF THE RAIL GAGES AT WEST END OF BRIDGE

FIG. 32

SANTA FE TIMBER TRESTLE TESTS

RECORDED LONGITUDINAL AND DIRECT STRESSES

BRIDGE 559.2 WBM



NOTE: FOR PILE GAGES ON BENTS 7 AND 8, THE TOP NUMBER INDICATES THE RECORDED STRESS VALUE FROM VERTICAL LOADS AND THE BOTTOM NUMBER INDICATES THE RECORDED STRESS VALUE FROM BRAKING TO A STOP ON THE BRIDGE.

RUN NO.	STRESSES FROM VERTICAL LOADS IN PSI AND STRESSES FROM BRAKING TO A STOP ON THE BRIDGE IN PSI																STRESSES FROM BRAKING TO A STOP ON THE BRIDGE IN PSI						
	GAGES ON BENT 8										GAGES ON BENT 7						RAIL GAGES				PRESSURE CELLS		*DIST. FT.
	59	58	57	56	55	54	53	52	51	50	65	64	63	62	61	60	1	2	46	47	3	4	
	STOPPING ON THE BRIDGE																						
322	-40 +20	-95 -26	-88 +16	-117 -30	-93 +12	-217 -25	-131 —	-176 -30	-129 +20	-65 -12	-29 +23	-60 -20	-135 +24	-217 -20	-244 +25	-97 -20	- 568	- 550	+ 763	+ 717	- 0.14	- 0.28	+17'-2
323	-55 +42	-97 -33	-129 +46	-126 -40	-166 +33	-259 -36	-246 +25	-229 -52	-191 +38	-83 -23	-25 +54	-64 -40	-127 +49	-217 -47	-246 +55	-108 -40	- 774	- 1000	+ 763	+ 768	- 0.32	- 0.50	-15'-11
324	— +30	— -27	— +26	— -24	— +19	— -23	— +8	— -24	— +24	— -12	-31 +33	-75 -33	-129 +23	-227 -42	-212 +25	-127 -38	- 826	- 850	+ 716	+ 512	- 0.51	- 0.48	+27'-10
325	-43 +38	-109 -33	-115 +41	-134 -31	-151 +40	-270 -29	-240 +31	-241 -42	-184 +43	-87 -15	-29 +48	-60 -42	-132 +38	-212 -44	-244 +40	-95 -38	- 1189	- 1150	+ 1336	+ 1536	- 0.24	- 0.30	+ 8'-6
326	-30 +37	-117 -36	-93 +41	-150 -40	-134 +31	-273 -32	-223 +20	-261 -50	-162 +36	-95 -20	-20 +46	-58 -40	-126 +24	-214 -30	-246 +47	-103 -32	- 1032	- 1000	+ 1383	+ 1690	- 0.33	- 0.51	+12'-7
327	-32 +38	-114 -36	-95 +38	-149 -40	-134 +29	-274 -36	-227 +20	-251 -52	-162 +35	-88 -20	-24 +46	-58 -38	-120 +42	-211 -46	-244 +49	-97 -31	- 1084	- 1150	+ 1622	+ 1792	- 0.32	- 0.50	+12'-3
328	— +40	— -42	— +38	— -40	— +29	— -36	— +12	— -42	— +33	— -20	-12 +46	-81 -40	-117 +44	-230 -42	-236 +55	-120 -38	- 1032	- 1100	+ 1336	+ 1741	- 0.38	- 0.59	+23'-5
329	0 +37	-109 -44	-38 +38	-120 -46	-31 +29	-188 -42	-115 +14	-168 -52	-74 +36	-63 -23	-26 +48	-64 -33	-127 +49	-214 -35	-237 +49	-97 -32	- 1032	- 1000	+ 1097	+ 1331	- 0.38	- 0.54	+19'-4
330	-59 +40	-97 -24	-134 +35	-122 -12	-172 +44	-261 -13	-246 +31	-212 -24	-190 +42	-75 -12	-40 +46	-54 -44	-139 +32	-203 -53	-247 +33	-88 -40	- 1187	- 1500	+ 1193	+ 1331	- 0.19	- 0.23	+ 2'-5
331	-40 +42	-115 -33	-103 +43	-145 -36	-149 +33	-276 -31	-235 +26	-250 -48	-171 +40	-89 -15	-20 +49	-64 -40	-121 +41	-212 -40	-245 +49	-108 -40	- 1126	- 1293	+ 1946	+ 2048	- 0.27	- 0.38	+10'-6
332	-49 +40	-105 -36	-122 +41	-132 -31	-160 +41	-269 -29	-241 +29	-229 -38	-185 +43	-83 -15	-33 +48	-63 -42	-132 +37	-206 -44	-247 +43	-93 -40	- 1084	- 1450	+ 1670	+ 1587	- 0.22	- 0.30	+ 8'-4
333	-37 +42	-101 -32	-108 +41	-139 -33	-148 +31	-273 -31	-235 +24	-245 -48	-174 +37	-87 -20	-31 +49	-60 -40	-135 +41	-206 -36	-250 +49	-93 -36	- 1135	- 1250	+ 2003	+ 1946	- 0.24	- 0.34	+ 11'-0
334	-55 +40	-99 -24	-128 +35	-128 -15	-166 +44	-269 -16	-246 +29	-230 -26	-191 +40	-83 -12	-33 +48	-58 -46	-135 +41	-208 -53	-252 +33	-95 -44	- 1238	- 1300	+ 1240	+ 1280	- 0.24	- 0.30	+ 3'-0
335	-58 +37	-103 -30	-126 +24	-128 -20	-163 +44	-259 -23	-241 +29	-223 -27	-185 +42	-81 -14	-25 +46	-63 -40	-126 +32	-212 -47	-250 +35	-103 -37	- 980	- 1250	+ 1670	+ 1690	- 0.17	- 0.19	+ 5'-8
	TRACTION																						
	STRESSES FROM STARTING ON THE BRIDGE IN PSI																						
338	- 8	+ 8	- 8	+ 6	- 6	+ 3	- 6	+ 8	- 3	0	-10	+ 8	- 8	+ 9	- 9	+ 8	+258	+300	-477	-563	+ 0.03	+ 0.02	+57'-1
339	- 6	+ 6	- 6	+ 6	- 8	+ 3	- 3	+ 8	- 3	0	-12	+ 8	- 9	+ 8	- 12	+ 8	+310	+250	-525	-512	+ 0.03	+ 0.02	+57'-1
340	-15	+ 9	- 12	+ 12	- 18	+ 16	- 16	+ 9	- 18	+ 8	-16	+15	- 14	+ 14	- 15	+ 9	+315	+400	-473	-563	+ 0.09	+ 0.09	+ 1'-6
341	- 9	+ 6	- 10	+ 6	- 15	+ 7	- 10	+ 6	- 12	+ 2	-10	+12	- 6	+ 14	- 12	+ 9	+361	+350	-191	-205	+ 0.06	+ 0.05	+ 1'-6

* THE MINUS SIGN INDICATES THE DISTANCE THE TRAIN STOPPED OR STARTED WEST OF THE RAIL GAGES AT WEST END OF BRIDGE AND THE PLUS SIGN INDICATES THE DISTANCE THE TRAIN STOPPED OR STARTED EAST OF THE RAIL GAGES AT WEST END OF BRIDGE.

FIG 33
SANTA FE TIMBER TRESTLE TESTS
TYPICAL OSCILLOGRAM

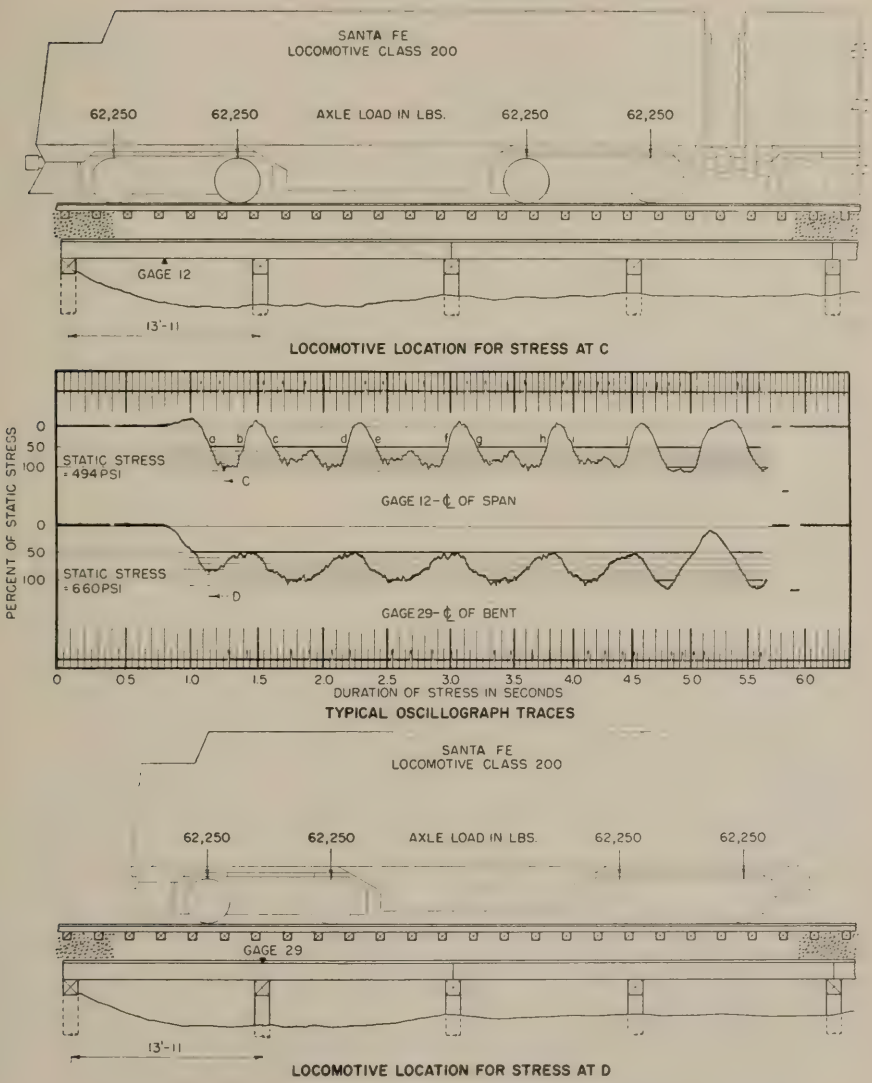


FIG. 34
SANTA FE TIMBER TRESTLE TESTS
AVERAGE DURATION OF STRESS
BRIDGE 558.8 EBM
LOCOMOTIVE CLASS 200

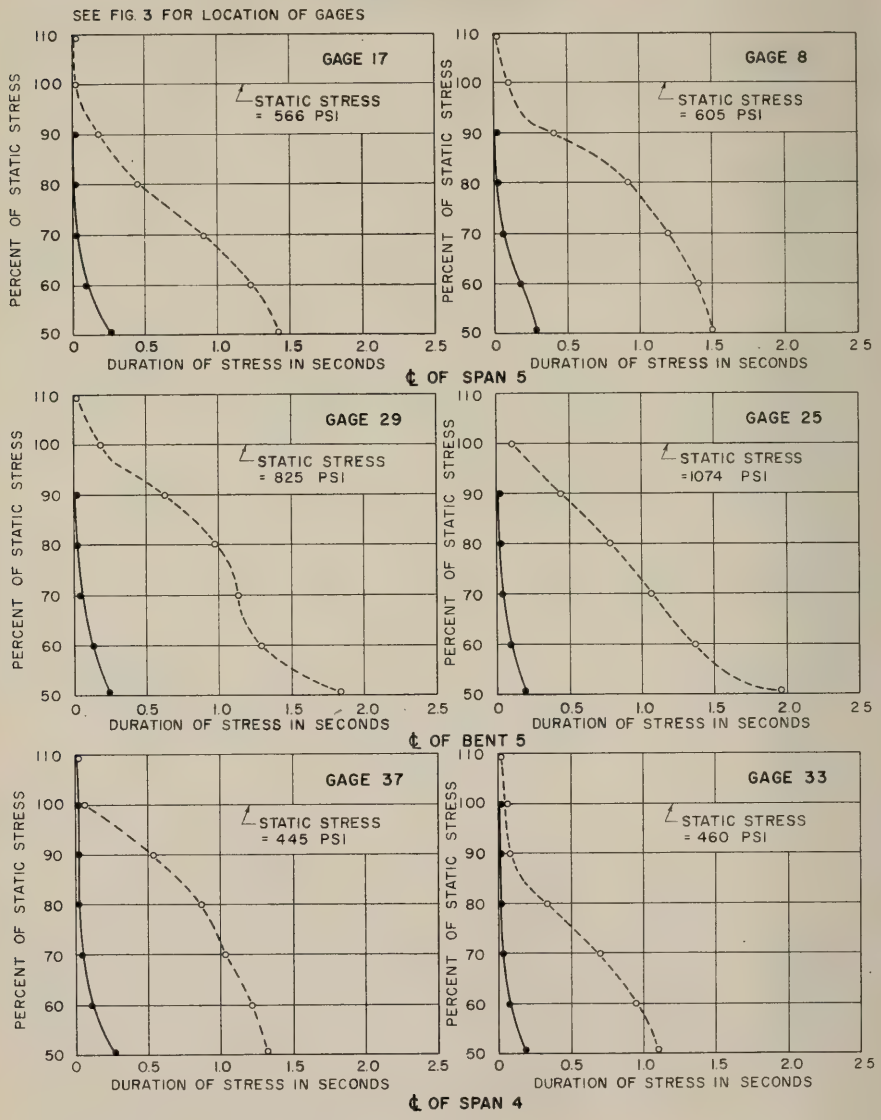


FIG. 35
SANTA FE TIMBER TRESTLE TESTS
AVERAGE DURATION OF STRESS
BRIDGE 558.8 EBM
LOCOMOTIVE CLASS 2650

SEE FIG 3 FOR LOCATION OF GAGES

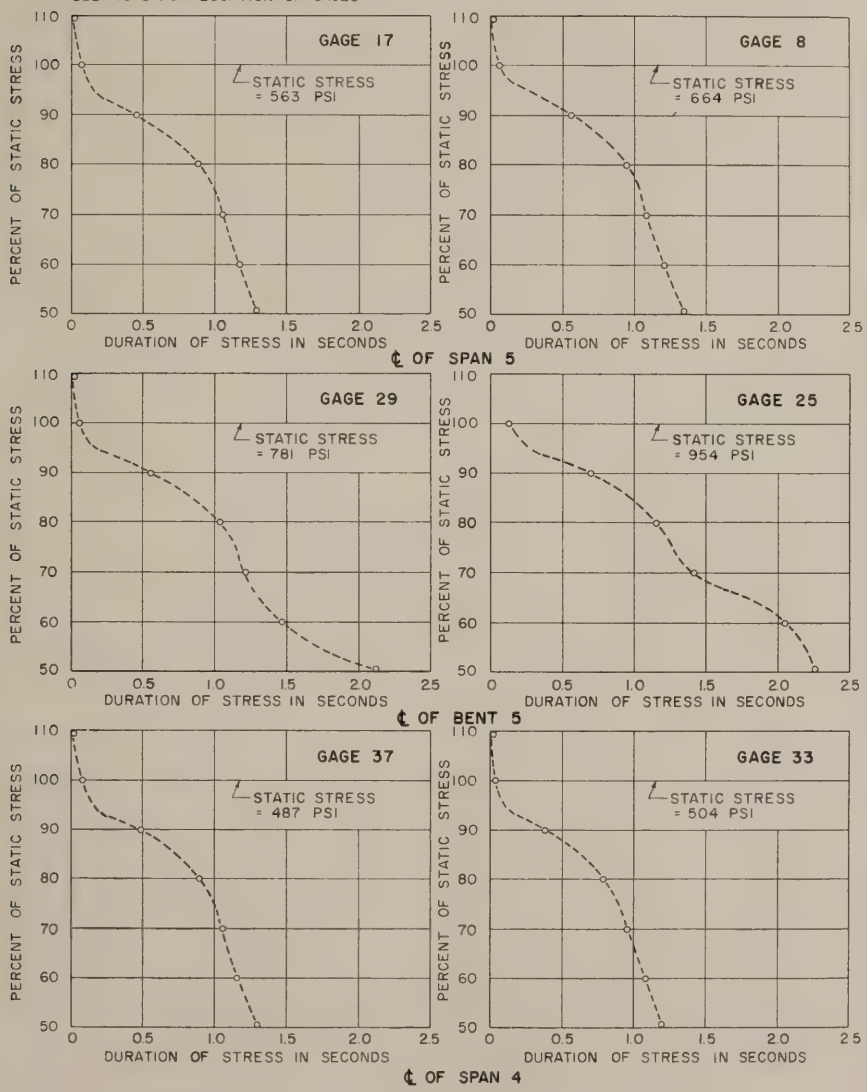


FIG. 36
SANTA FE TIMBER TRESTLE TESTS
AVERAGE DURATION OF STRESS
BRIDGE 558.8 WBM
LOCOMOTIVE CLASS 200

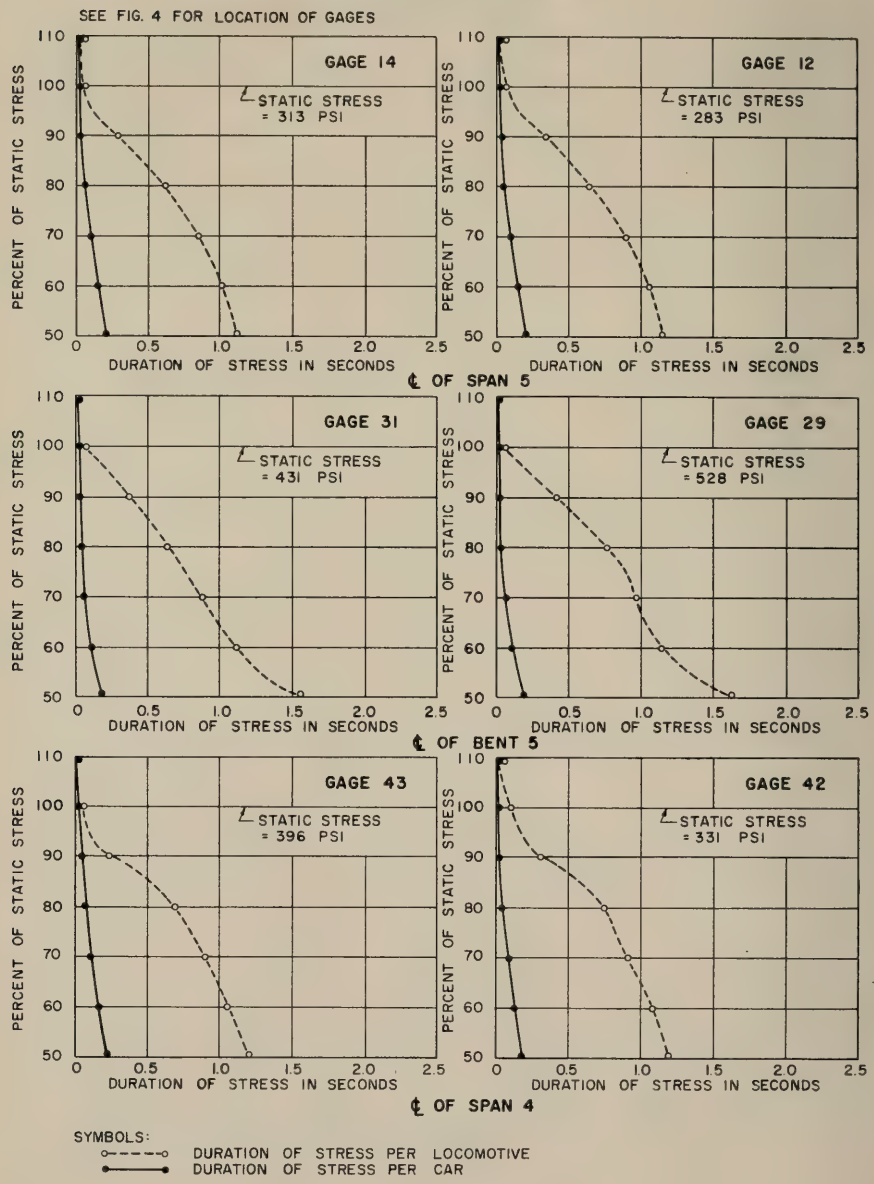


FIG. 37
SANTA FE TIMBER TRESTLE TESTS
AVERAGE DURATION OF STRESS
BRIDGE 559.2 EBM
LOCOMOTIVE CLASS 2650

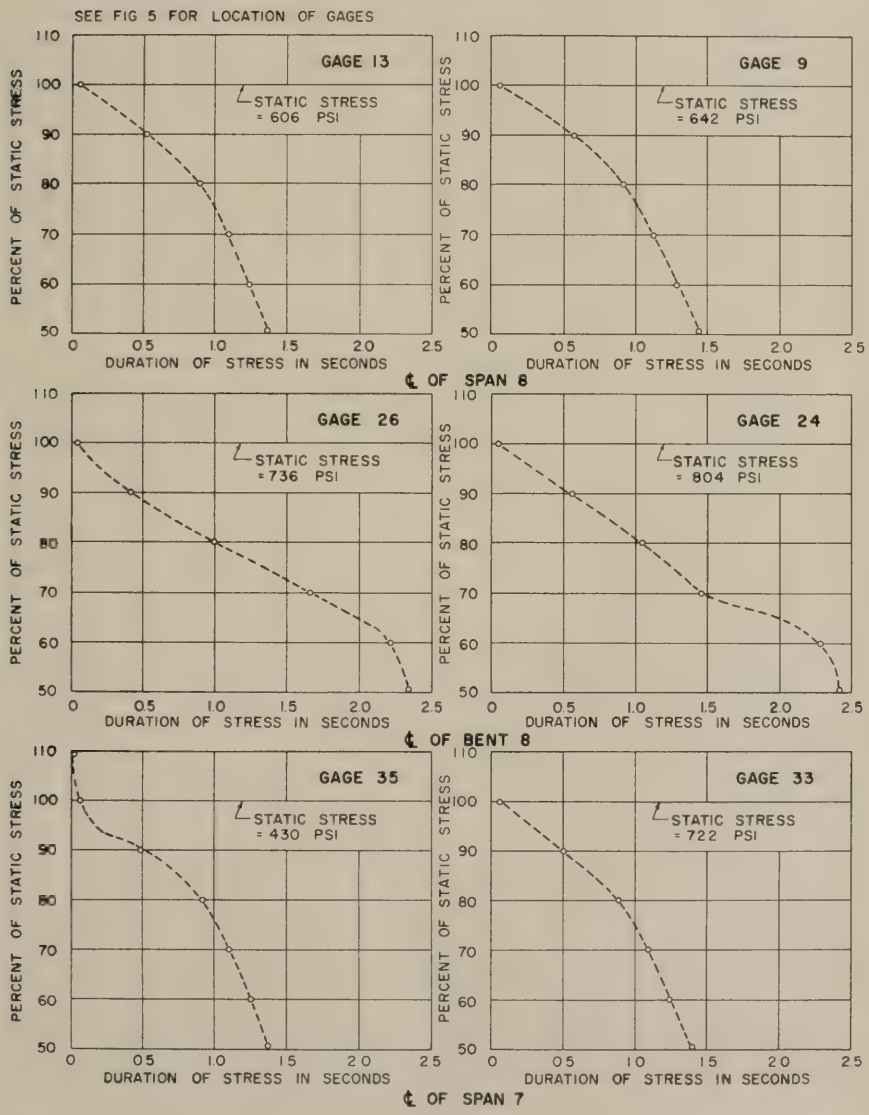


FIG 38
SANTA FE TIMBER TRESTLE TESTS
AVERAGE DURATION OF STRESS
BRIDGE 559.2 EBM
LOCOMOTIVE CLASS 200

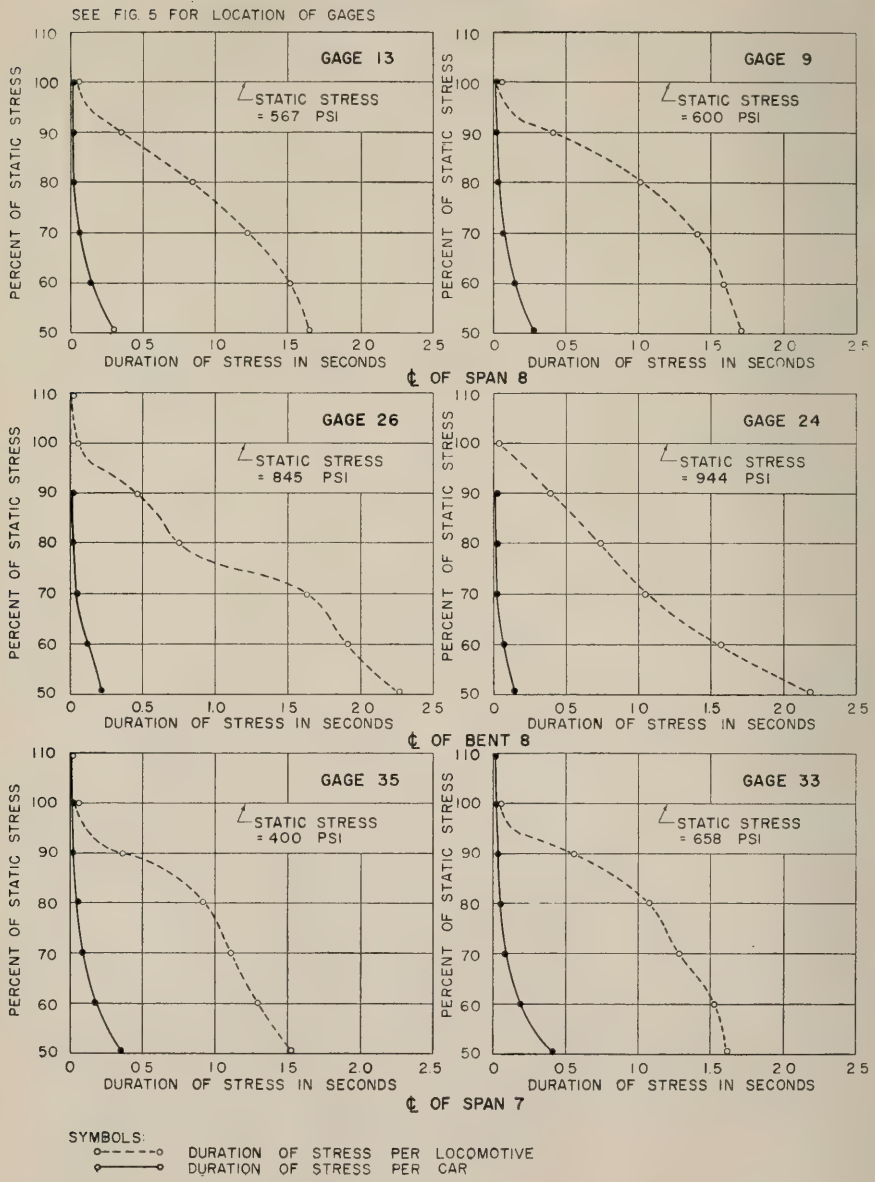


FIG 39
SANTA FE TIMBER TRESTLE TESTS
AVERAGE DURATION OF STRESS
BRIDGE 559.2 WBM
LOCOMOTIVE CLASS 200

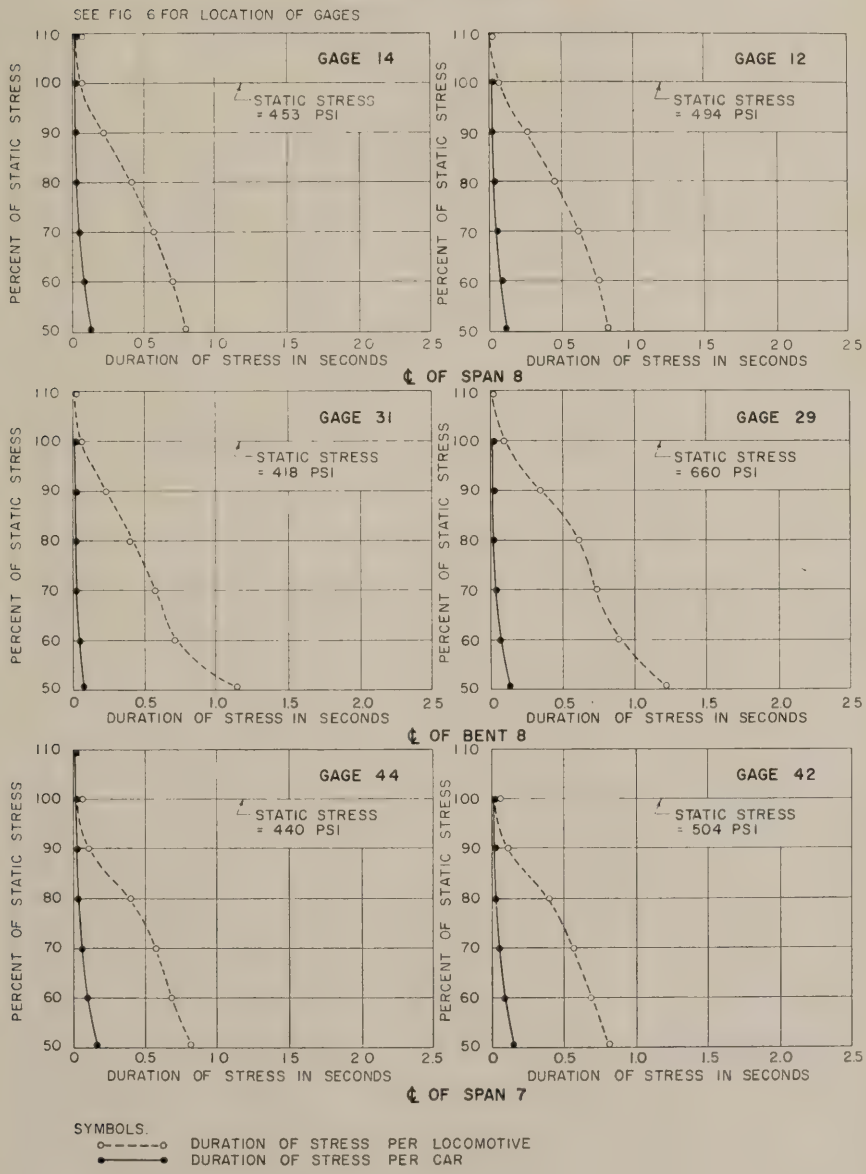
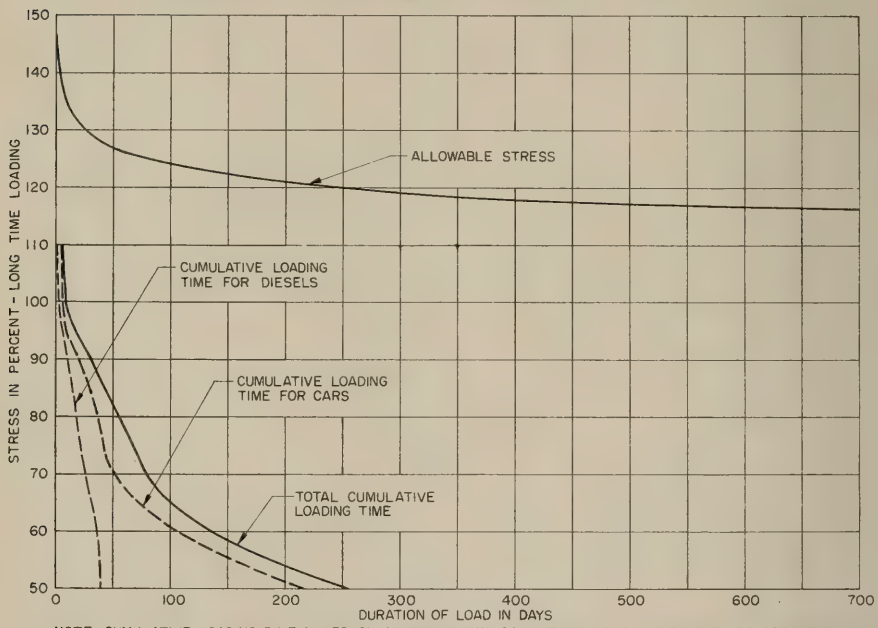


FIG. 40
SANTA FE TIMBER TRESTLE TESTS
CUMULATIVE LOADING TIME WITH RESPECT TO STRESS



NOTE: CUMULATIVE LOADING TIME BASED ON 25 TRAINS PER DAY WITH 3 DIESEL UNITS AND 100 CARS EACH FOR 50 YEARS.

Advance Report of Committee 29—Waterproofing

E. A. Johnson, *Chairman*

Factors Affecting the Penetration by Water of Bituminous and Silicone Coatings

By W. L. Dolch

Research Associate, Joint Highway Research Project, Purdue University

INTRODUCTION

The usefulness of a water-resisting coating is largely dependent on its capability of being water resistant to the required degree and on its ability to maintain this quality despite the effects of weathering processes.

This study deals with two types of coatings in common use—bituminous emulsions and silicone resins. They function by essentially different mechanisms when used to protect a porous material, such as concrete. The bituminous emulsion forms a film that should present a continuous barrier between the substrate to be protected and the water. A silicone lines the pores of a porous material with a thin layer of resin that prevents the entrance of water by means of a capillary repulsion mechanism.

The amount of water that penetrates an intact film of bituminous material is so small that it can, for practical purposes, be neglected. The failure of these materials to prevent the passage of water is largely due to the presence of imperfections in the coating. Cracks and pinholes are all too common in bituminous coatings and are the result either of imperfect application of the material or of degredation of some kind. The importance of good workmanship during application is obvious.

If imperfections are large, water will enter readily. If, however, they are small, which is frequently the case, water may be denied entrance to the crack or pinhole by the same sort of capillary repulsion mechanism that is operative for the silicone materials. In a sense, therefore, the capillary properties of both these types of coatings are important to their serviceability.

The ease with which water penetrates a small channel by capillarity is determined partly by the contact angle of water on the material. The contact angle is the angle, measured in the liquid, between the surfaces of the solid and the liquid at a three-phase boundary. In the case where water and air are the liquid and gaseous phases in question, the water is said to wet the solid if the contact angle is less than 90 deg and not to wet the solid if it is greater than this value. If the angle is less than 90 deg the water will be drawn into a small capillary channel. If it is more than 90 deg the water will be denied entrance to the channel, and it will be necessary to impose external pressure to cause entrance. The magnitude of the capillary pressure that either causes spontaneous entrance into a solid that is wet by water or that must be overcome by applied pressure to force entrance into a channel that is not wet by water is given, for a pore small enough so that the meniscus of the water can be considered a spherical section, by

$$P_c = \frac{2\,\gamma \cos\theta}{r} \qquad (1)$$

where γ is the surface tension of the liquid, θ is the contact or wetting angle, r is the radius of the channel, and P_c is the capillary pressure. Transposed into terms of the head that will be maintained, this equation becomes the well-known capillary-rise formula

$$h = \frac{2\,\gamma \cos\theta}{r\,\rho\,g} \qquad (2)$$

where ρ is the density of the liquid, g is the gravitational acceleration, and h is the head

that will exist in a wetted channel or must be imposed to force entrance into a non-wetted one.

These relationships are shown pictorially in Fig. 1 which shows two capillary tubes immersed in a liquid. In (a) the contact angle is less than 90 deg, the solid is wet by the liquid, and the liquid is drawn into the channel. In (b) the angle is greater than 90 deg, the solid is not wet, and the liquid is depressed in the channel.

Obiviously, for water resistance, any entrance into the substrate should be composed of or lined with a material that is not wet by water. Otherwise, water will be drawn into the opening, and the waterproofness of the treatment will be offset to some extent.

If there is any structural possibility of water standing on the surface in question,

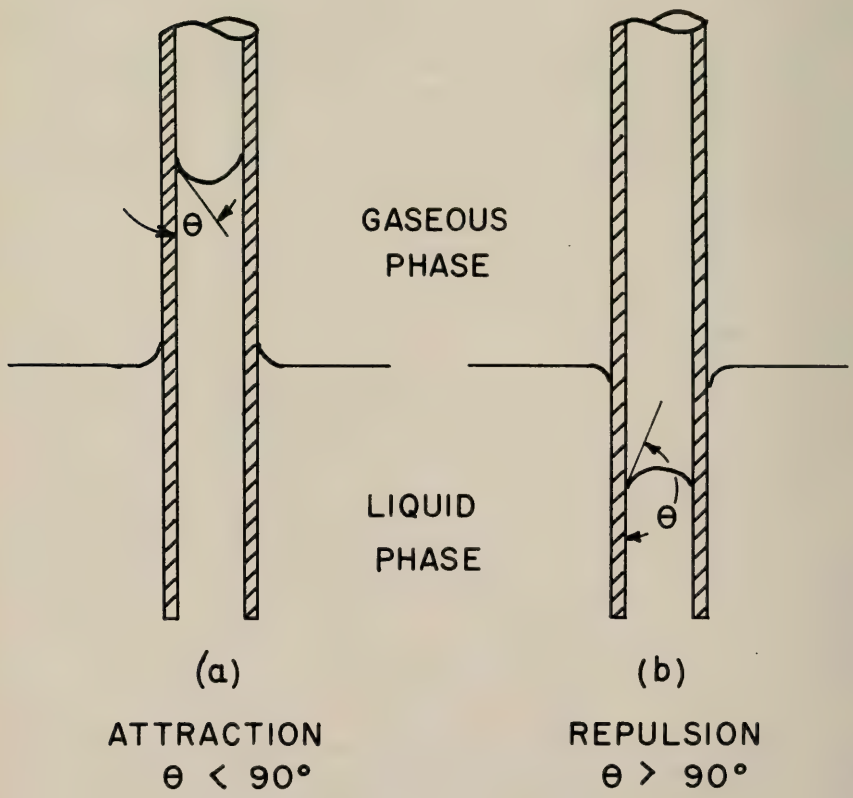


FIG. 1 CAPILLARY ATTRACTION AND REPULSION

then the larger the contact angle the better, because the head that can be withstood without entrance of water into the pores or imperfections will be greater.

So the contact angle is a property that is important to the effectiveness of water-resistant coatings of either of the types in question.

The purpose of this work was to measure the contact angles of water on the various materials and to discover how this angle is influenced by certain weathering exposures.

EXPERIMENTAL WORK

Materials

The waterproofing effectiveness of the bituminous emulsions was evaluated in a previous study (1)*. Fresh samples of these materials were obtained from the manufacturers, including three coal-tar emulsions, four soap-type asphalt emulsions, two soap-type asphalt emulsions containing mineral filler, and five clay-type asphalt emulsions. These emulsions were analyzed for water content by distillation in the usual way (ASTM Designation D 244) and for ash content by ignition at red-heat in a platinum crucible. The results of these determinations are given in Table 1.

TABLE 1—RESULTS OF ANALYSES OF BITUMINOUS EMULSIONS

Code No.†	*Type*	*Water Content %*	*Ash Content %*
M 5	Coal tar	40.6	20.8
M 15	Coal tar	48.4	19.9
M 17	Coal tar	54.2	12.4
M 6	Soap-type asphalt	41.7	0.9
M 13	Soap-type asphalt	31.0	0.4
M 19	Soap-type asphalt	38.7	0.5
M 26	Soap-type asphalt	42.3	0.7
M 7	Soap-type asphalt, filled	58.4	17.2
M 8	Soap-type asphalt, filled	56.9	19.5
M 9	Clay-type asphalt	54.6	3.3
M 14	Clay-type asphalt	46.4	2.6
M 22	Clay-type asphalt	44.8	3.3
M 23	Clay-type asphalt	47.2	6.3
M 24	Clay-type asphalt	48.2	5.2

†These code numbers are the same as those used in the earlier report on these materials (1).

The silicones were manufacturers' samples in the form of concentrated solutions that required dilution before application. Three were so-called solvent-base materials that are applied as hydro-carbon solutions. Evaporation of the solvent leaves the residual film of silicone resin. Two were the so-called water-base materials. These were solutions of substituted siliconic acids that are applied as water solutions and develop the coating resin by evaporation of the water and reaction with atmospheric carbon dioxide. Both types are in common use as water-resistant materials. The five silicones represented the products of three different manufacturing companies. It should be emphasized that the silicones were obtained direct from the manufacturers and had not been compounded by secondary formulators. As such they were the pure materials and did not contain any additions, "builders", or what not.

* Numbers in parenthesis refer to references in the bibliography at end of this report.

Sample Preparation

The bituminous materials were tested in the form of discrete films prepared by using amalgamated brass molds that had hollows approximately 4 in. in diameter and 0.04 in deep machined into them. The emulsion was "buttered" into this hollow with a spatula and worked carefully to eliminate air bubbles. The surface was then smoothed level with the top of the mold. An empty mold and the smoothing operation are shown in Fig. 2. The mold and its contents were set aside to dry, and the finished films were

Fig. 2—Preparation of emulsion films.

removed the next day. The films so obtained were approximately 0.02 in thick and showed no imperfections when viewed against a strong light. The reason for making the test films in this way was that surface roughness influences the contact angle of a liquid on a solid. The films prepared in the manner described had one surface that was extremely smooth.

The prepared bituminous films were then applied to 6- by 6-in glass plates. The asphalt materials stuck to the glass with the application of only a little pressure. With the tars it was necessary to use a cement, made by melting a small amount of straight tar, to get the film to stick to the glass plate. Duplicate samples were made of all the bituminous films and were applied to the plates with the smooth surface of one and the rough surface of the other uppermost so that a check could be made on the importance of surface roughness. The only exception was for the soap-type asphalt emulsions that were so ductile that they could not be removed intact from the molds. These were tested directly in the molds and on the rough side only, but because of the comparatively high fluidity of these materials the "rough" surfaces were fairly smooth.

The silicones were also applied to 6- by 6-in glass plates. The stock solutions were diluted according to the manufacturers' instructions. These diluted solutions were applied to the glass plates with a cloth. An effort was made to obtain complete and uniform coverage. Several concentrations of the solutions were used.

Measurement of Contact Angles

When considering the measurement of contact angles it is important to understand exactly what is being measured. The cleanness of the solid surface, the purity of the liquid phase, the degree of roughness of the solid surface, and the way in which the experiment is performed all influence the value that will be obtained for the contact angle. For the purposes of this study, the important question is whether water will enter an imperfection in a coating or a lined pore of the concrete. The concern, therefore, is with the wetting angle of reasonably pure water on the coating materials in the ordinary state of equilibrium with the water vapor, oil, and other impurities of the normal atmosphere. The concern is also with the condition where the water is advancing over the solid (advancing contact angle) rather than retreating from an area it had previously been covering (retreating contact angle). These two angles will usually be considerably different. What was desired, therefore, was to measure the advancing "apparant" contact angle rather than any angle characteristic of the pure, clean, ideally smooth materials. These questions are discussed in detail along with methods of measuring the contact angle in standard references (2, 3, 4, 5).

The method chosen for these samples consists of measuring the height of a sessile drop of the liquid resting on the solid surface. This method is described by Adam (4) who gives an easily derived equation

$$\cos\theta = 1 - \frac{\rho g d^2}{2r} \qquad (3)$$

in which d is the thickness of the sessile drop and all the other terms are as previously defined. For extreme accuracy with this method it is necessary to use comparatively large drops, but the error in using smaller drops is not great. Those used in this study were 3 to 4 in. in diameter.

The method of measuring the drop height is shown in Fig. 3. The plate supporting

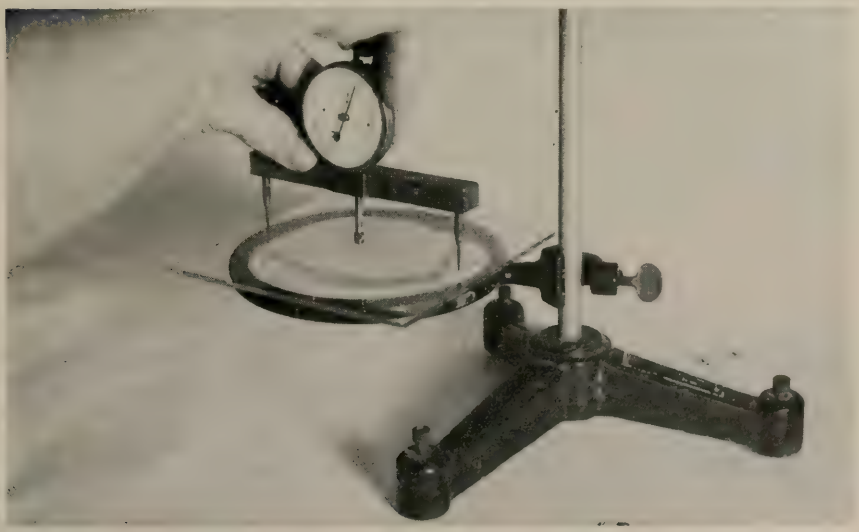


Fig. 3—Measurement of drop height.

the sample (a siliconed plate is shown in the figure) was placed on a ring mounted on a stand with levelling screws in its feet. The plate was levelled with the aid of a small circular spirit level. The drop of water was then applied from a medicine dropper. When it was as large as feasible its height was measured, using an Ames dial in the special frame. The plunger of the dial was lowered gradually until it touched the water surface, and the dial was read at this point. Repeated measurements on the same bubble gave a reproducibility of about 0.002 in. The temperature of the water was measured in order to know the correct values of surface tension and density for use in Equation 3.

Weathering Processes

Two weathering processes were applied to the samples to determine the changes that take place in the contact angle of water on the materials. One was a wetting and drying technique and the other was exposure to accelerated action of light, air, and water in a laboratory weathering machine.

The wetting and drying test was applied only to the bituminous films and was carried out as follows: The contact angles were determined when the films were taken from the molds and applied to the test plates. The samples were then dried in a dessicator over magnesium perchlorate for three days and the angles were again determined. The samples were immersed in tap water and the angles were determined after the films had been immersed for 1 hr, 1 day, and 2 days. For these measurements the film surfaces were blotted surface dry, i.e., all free water was removed, and the sessile drop was then applied. After this wetting period the samples were returned to the dessicator and the contact angles were determined after 1 and 3 days of drying.

The accelerated weathering tests were performed on both the bituminous and the silicone samples except for the straight soap-type asphalt emulsions that were too temperature-susceptible for exposure to the somewhat elevated temperature of the weathering machine. Also, not all of the bituminous samples of the other classes were used in this type of exposure. Separate samples of the bituminous films were used for the weatherometer and the wetting-drying exposures. The plates to which the samples had been applied were mounted at about a 45-deg angle in the machine. This machine was an Atlas Model X1–A carbon-arc machine that subjected the samples to continuous visible and ultra-violet radiation and to an intermittent soft-water spray. The contact angles of water on the materials were determined at intervals of about 10 hr exposure. Total exposures ranged approximately from 200 to 400 hr. Duplicate samples were run for the bituminous materials because of their presumably less uniform consistency. They were weathered on only the "smooth" sides of the films. Only single samples of coatings made with the silicone solutions were weathered.

DATA

The results of the determinations of contact angles on the bituminous films subjected to the wetting and drying process are given in Table 2. The headings at the top of the table indicate the stage of the wetting-drying treatment at which the contact angles in the column underneath were determined.

The results of the measurements on the bituminous films subjected to the accelerated weathering are given in Figs. 4 to 6. All samples tested are shown in the figures. Each data point is the average of duplicate determinations. In these and the following figures the scales are identical in order to facilitate comparisons.

The results of the determinations on the silicone samples exposed in the weatherom-

TABLE 2—CONTACT ANGLES*—WATER ON BITUMINOUS EMULSION FILMS

Code No.	Out of Molds		3 Days Dry		1 Hr Wet		1 Day Wet		2 Days Wet		1 Day Dry		3 Days Dry	
	S**	R	S	R	S	R	S	R	S	R	S	R	S	R
Coal-Tar Emulsions														
M 5	97	99	110	114	102	105	96	96	76	81	110	116	111	116
M 15	96	84	107	104	----	----	65	69	56	66	----	----	103	105
M 17	106	96	103	100	96	96	84	84	75	77	108	106	108	104
Asphalt Emulsions, Soap Type														
M 6	----	99	----	112	----	----	----	109	----	85	----	116	----	111
M 13	----	110	----	113	----	----	----	120	----	108	----	117	----	119
M 19	----	117	----	112	----	----	----	115	----	107	----	118	----	116
M 26	----	109	----	112	----	----	----	58	----	63	----	116	----	112
Asphalt Emulsions, Soap Type, Filled														
M 7	108	123	107	123	100	103	----	----	96	96	116	123	121	127
M 8	109	100	129	119	106	90	119	90	95	85	120	121	123	127
Asphalt Emulsions, Clay Type														
M 9	102	104	115	112	94	94	33	60	----	----	123	119	122	114
M 14	96	110	115	118	112	111	96	102	104	107	117	117	119	116
M 22	113	118	116	123	112	110	112	111	104	101	123	117	119	119
M 23	98	102	115	115	106	106	105	107	100	106	112	116	115	119
M 24	96	----	115	-	114	----	102	----	114	----	119	----	122	----

*In degrees.
**S refers to smooth and R to rough side of the film.

eter are shown in Figs. 7 to 9, incl. Not all the data obtained are shown in these figures because it was felt that a complete report of the data would have resulted in figures so crowded as to detract from the meaning. Of course, no data were omitted that showed what were considered to be significant differences. Specifically, material S2 was tested at concentrations of 1 and 5 percent as well as the 3 percent shown in Fig. 7. The other two runs were not included in the figure because the maximum variation among the three at any time was 10 deg and the average variation was only about 3 or 4 deg. Since the three concentrations performed so much alike, with variations that are probably not significant considering the experimental errors involved, it was felt that only one curve for this material need be shown. Similar considerations prevailed with respect to materials S3 and S4. Material S3 was tested at 1 and 3 percent and S4 at 1, 3, and 10 percent as well as at the 5 percent concentrations shown in Fig. 8. Only silicone S5 showed a large dependency of contact angle on concentration. The complete data for this material are, therefore, shown in Fig. 9.

DISCUSSION

The error in the measurement of the sessile drop height is such as to introduce an uncertainty of about 2 deg into the values for contact angle. One of the deficiencies of this work is that a statistical study should have been made to determine the over-all precision of this method of determining contact angles when used on materials such as these. Based on a limited number of duplicate tests and on the degree of agreement between the values for "smooth" and "rough" surfaces of the same material, it is probable that the measurements have a precision of about ± 4 deg. That is, changes of less than about this magnitude can probably be ascribed to experimental error rather than any other significance being attached to them.

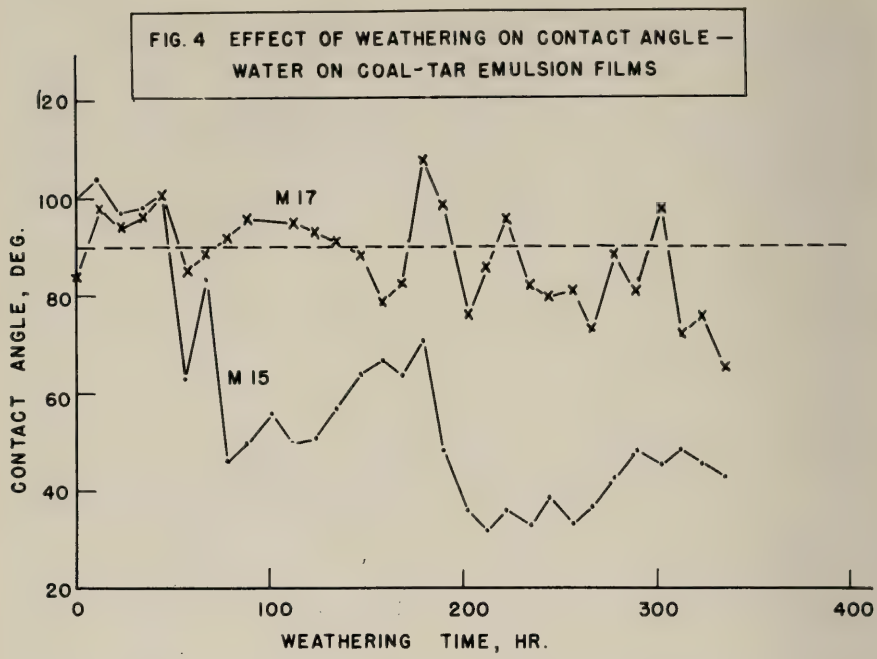


FIG. 4 EFFECT OF WEATHERING ON CONTACT ANGLE — WATER ON COAL-TAR EMULSION FILMS
CONTACT ANGLE, DEG.
120
100
80
60
40
20
M 17
M 15
0
100
200
300
400
WEATHERING TIME, HR.

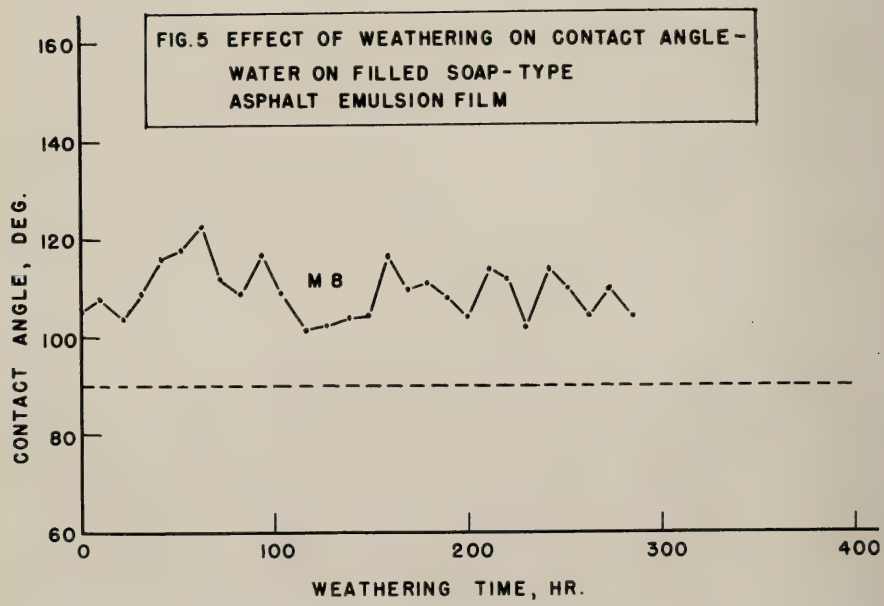
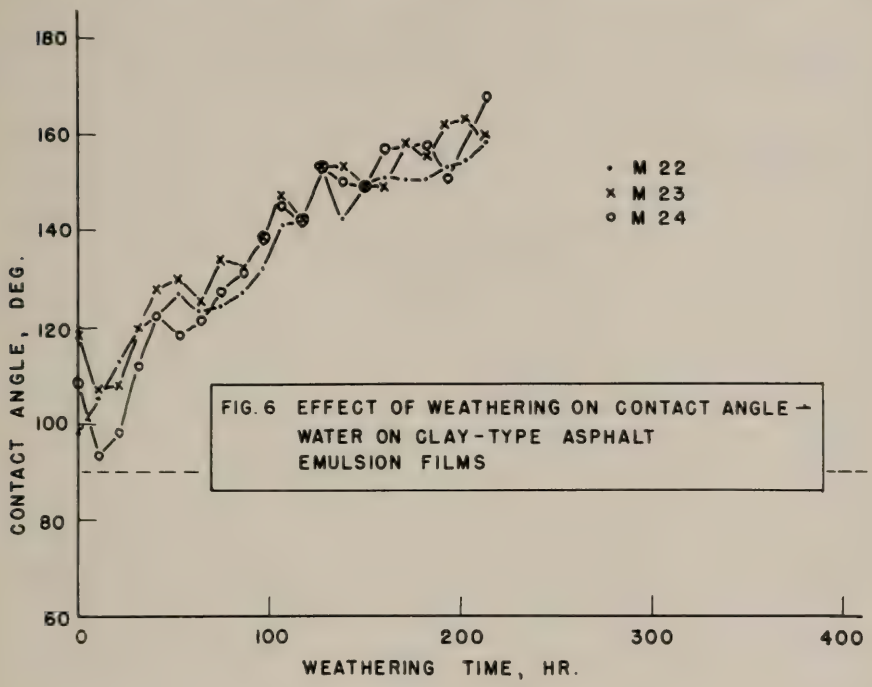


FIG. 5 EFFECT OF WEATHERING ON CONTACT ANGLE - WATER ON FILLED SOAP-TYPE ASPHALT EMULSION FILM
CONTACT ANGLE, DEG.
160
140
120
100
80
60
M 8
0
100
200
300
400
WEATHERING TIME, HR.



Inspection of Table 2 shows that all the bituminous coatings had a decreased contact angle after immersion in water and that the angle increased again on subsequent drying. This behavior can be explained on theoretical grounds. The relationship between the contact angle and the three interfacial tensions present at a solid-liquid-gaseous interface is given by the so-called Young equation

$$\cos\theta = \frac{\gamma_s - \gamma_{sl}}{\gamma_l} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where γ_l is the surface tension of the liquid, γ_s is the surface free energy of the solid—or more correctly of the solid and any adsorbed surface layers it may have—and γ_{sl} is the interfacial tension of the solid-liquid interface. Assuming γ_l to be constant, θ will decrease if γ_s increases or if γ_{sl} decreases. When the bituminous films are immersed in water a small amount of the water will dissolve in the surface layers of the film. The presence of this water would be expected to lower the interfacial tension γ_{sl}. Values of the surface tension of asphalts have been reported (6) to be about 30 dynes per cm. The value for water at room temperature is about 72 dynes per cm. If it is considered that the surfaces of these emulsion films are essentially bitumen surfaces, then the presence of dissolved water in the surface layer should increase the surface tension or surface free energy of the solid γ_s. Both these effects tend to decrease the wetting angle, and this is perhaps the explanation of the observed changes. The effect of subsequent drying would be the reverse of the above explanation.

In the dry state all the tested materials had contact angles with water larger than 90 deg. They would, therefore, repel water from imperfections and would serve their

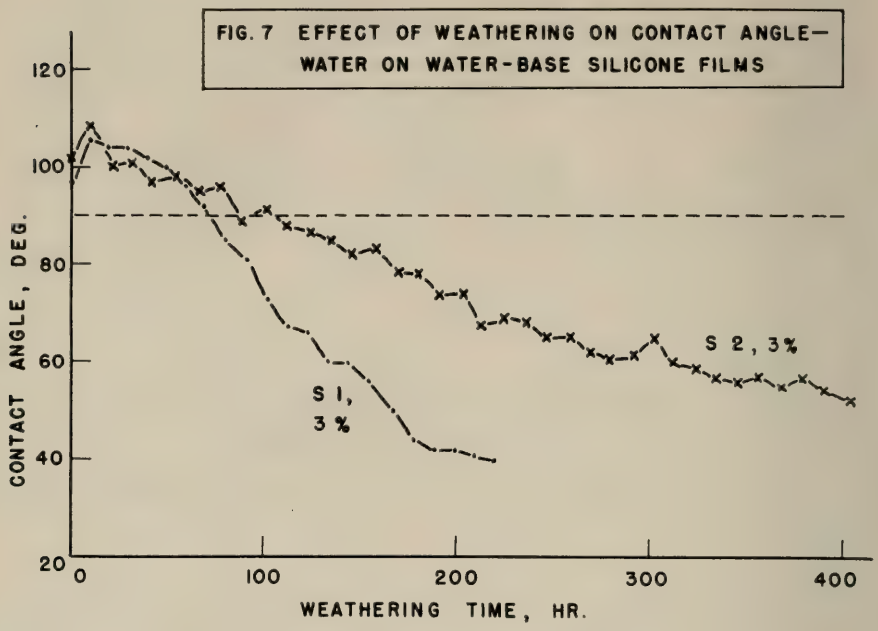


FIG. 7 EFFECT OF WEATHERING ON CONTACT ANGLE—
WATER ON WATER-BASE SILICONE FILMS
CONTACT ANGLE, DEG.
120
100
80
60
40
20
0
100
200
300
400
WEATHERING TIME, HR.
S 2, 3%
S 1,
3 %

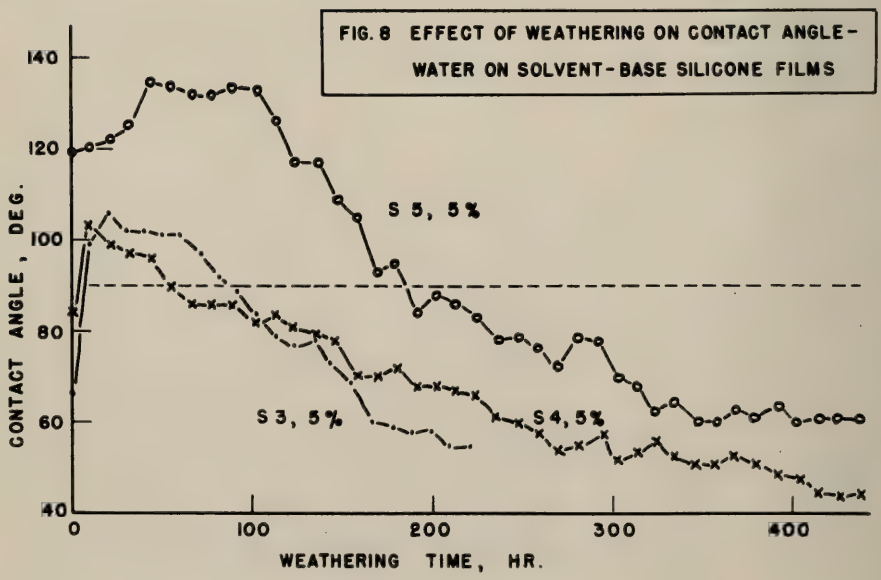
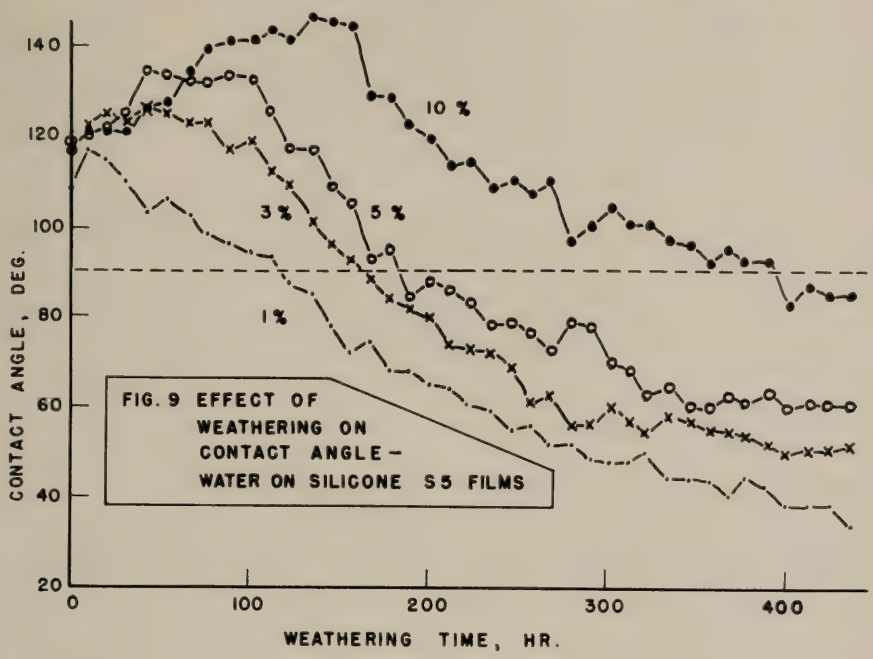


FIG. 8 EFFECT OF WEATHERING ON CONTACT ANGLE-
WATER ON SOLVENT-BASE SILICONE FILMS
CONTACT ANGLE, DEG.
140
120
100
80
60
40
0
100
200
300
400
WEATHERING TIME, HR.
S 5, 5%
S 3, 5%
S 4, 5%



water-resisting function in this respect. If, however, the head of water that could be withstood by a hole of "typical" size is calculated, the importance of good workmanship, design, and drainage in order to prevent excessive head is obvious. For instance, if the hole is considered to have a diameter of 0.5 mm, i.e. 20 mils, the capillary head that could be withstood by a material whose contact angle with water is 110 deg is only about 0.8 in.

Some of the materials showed a decrease of contact angle on wetting to a value of less than 90 deg. These materials would actively imbibe water through any imperfections. This statement is especially true of the coal-tar emulsions, all of which showed decreases of angle to less than 90 deg. Of the other materials the clay-type emulsions seemed to maintain a high angle the best as a group, but there are exceptions, and there are not enough data to generalize very far. The comparatively large decreases in contact angle on the tar materials may be explained by an increased solubility of water in the surfaces of these films due to the presence of polar compounds in the tar. This is the reason offered by Beckman et al (7) for similar low values obtained on straight tar pitches.

These results seem to show the importance of keeping coatings of these materials as free from continuous contact with water as possible.

With respect to the effects of accelerated weathering on the bituminous materials it is important in considering the data in Figs. 4 to 6 to remember that small variations in measured contact angle may not be significant, as they may be due only to experimental error.

The three classes of materials tested seem to be influenced by weathering in different

ways. As seen in Fig. 4, the tar emulsion films have their contact angles with water lowered by continued weathering and both fell below 90 deg in the course of the experiments. A possible explanation is that tars contain a considerably higher quantity of aromatic compounds than asphalts. If these compounds are oxidized by the action of accelerated weathering, the products might be polar compounds that would increase the affinity of the surface for water, decrease γ_{sl} in Equation 4, and therefore cause a decrease in the contact angle.

From a practical point of view the decrease in angle would mean a lessened ability of the material to waterproof the substrate in accordance with the mechanism previously described.

There are more abrupt fluctuations in the curves for the tars than for some of the other classes of materials tested. No explanation can be given for them except the highly speculative one that the weathering cycle did not always stop at just the same point with respect to the period of spray wetting. If the tars are more susceptible to surface changes than the asphalts—as they seem to be—the effects of different amounts of residual water in the surfaces might show up as wider fluctuations of measured contact angle.

Fig. 5 shows that one filled soap-type asphalt emulsion maintained the high contact angle throughout the weathering that it had at the beginning. Again there are rather abrupt and wide fluctuations, but the trend to a fairly constant value is perhaps the significant feature. It is known that asphalts oxidize to form oxygenated, and presumably polar, compounds (6) but if the mechanisms advanced here are valid this process seems to occur more slowly or to a lesser degree with the asphalts than with the tars.

Fig. 6 shows that the contact angles of water on the three clay-type asphalt emulsions become, except perhaps for a slight initial decrease, consistently larger as accelerated weathering progresses.

This increase to rather high values is seemingly inconsistent with the statement by Adam (8) that real contact angles greater than 120 deg cannot exist for water on an organic substance. The explanation may lie in the change that can take place in the "roughness factor." If the roughness of a surface is increased, i.e., if the ratio of the real surface area to the apparent or geometric area becomes larger, the contact angle will become larger for a non-wetting liquid (and smaller for a wetting liquid). The relationship has been expressed by Wenzel (9) as

$$\cos \theta' = \delta \cos \theta \qquad (5)$$

where θ is the "true" contact angle, θ' is the "apparent" contact angle and δ is the aforementioned roughness ratio. If the surfaces of the clay-type asphalt emulsions become roughened by the weathering, the contact angle with water could change in the measured manner. There is some reason to think that this could occur with the clay-type but not with the soap-type asphalt emulsions. The clay-type emulsions have a considerable structural rigidity due to the "honeycomb" nature of dried clay encasing the asphalt phase. This rigidity presumably extends to the surface and might be maintained while weathering of parts of the surface proceeded. This might give rise to an increase in the roughness of the surface. The soap-type emulsions, on the other hand, do not have this structural rigidity, and their surfaces are probably straight asphalt and possess only the rigidity they may get from an added filler. The surfaces would then adjust to the effects of weathering, and no great increase in the surface roughness would occur. If this hypothesis is correct, it could explain the differences in performance between the two types of material as exemplified in Figs. 5 and 6.

Whether this increase in contact angle would render the material better able to repel water from imperfections would depend on whether the effects of weathering were manifested on the area inside the imperfections or only on the overt surface. If the weathering effect was the same in both locations then there is the possibility that weathering would improve the serviceability of this type of material. On the other hand, the "self-healing" properties of the more ductile soap-type asphalt emulsions should be kept in mind.

Figs. 7 to 9 show a characteristic pattern for the weathering response of all the silicone films. The contact angle first increases—in some instances considerably—and then falls fairly constantly, and finally tapers off at some lower value—in every case less than 90 deg. Also, the higher the concentration of solution from which the film was made the larger the contact angle at any stage of the weathering process. This concentration dependency was, however, marked for only material S5.

The initial increase in angle may be due to further curing of the film in the weatherometer. The decrease could be due either to a removal of the film from the glass in localized sites by the weathering or to a general change to a more hydrophilic nature of the surface of the film. Since the coverage was always as complete as possible for all the concentrations tested, it is probable that the latter mechanism is responsible. This matter may be important because a complaint about silicone coating materials has been that they loose their effectiveness with time. These data bear out this reputation. But the degree to which the surface is harmed (in terms of water resistance) by weathering is, in a synthetic material like a silicone, subject to some control by changes in the constitution of the substance. Such changes have, no doubt, been made in recent years, since modern silicone waterproofers seem to be much better than their earlier counterparts. Some test such as the one reported here might be a sensitive index to effective changes in the nature of these substances.

A further aspect of these curves is the large contact angle measured on some of the films. For instance, the higher concentrations of material S5 gave angles at one stage in the process considerably higher than the 120-deg limit mentioned by Adam (8). Since it would seem a little difficult to invoke roughness as an explanation of the increase in the case of these materials it may be that Adam's estimate should be revised upwards—perhaps to 140 deg.

The behavior of material S5 (Fig. 9) is perplexing because of the large dependence shown by the contact angle on the concentration of the original silicone solution. That is, the same material should be deposited from the solution whatever the concentration. A higher concentration should give a thicker film, but the contact angle with water ought to be the same. The behavior of the other silicone materials bears this out since, as previously stated, the influence of concentration is fairly small. But with material S5 the behavior shows a dependence on concentration that implies that the weathering does more than just change the surface molecular layers.

The silicone data curves show that different materials can have different reactions to weathering at the same concentration. With respect to water-resisting ability, it would seem that those materials that maintained a high—specifically, greater than 90 deg—contact angle the longest would be the best. The concentrations for which the data are shown in Figs. 7 and 8 are approximately those recommended by the manufacturers for treating masonry materials. Other factors operate to influence a silicone's over-all water-resisting ability, however, and it is probably dangerous to generalize too far on the basis of only one criterion of superiority.

It should also be mentioned that a pore-lining material such as a silicone may protect the porous material from entrance of water even though the contact angle is less than 90 deg. This action could come about by the "overturning of the meniscus" at constrictions in the capillary channel as described by Adam (8). However, the larger the angle the better in any event.

CONCLUSIONS

Based on the materials tested and the tests performed, the following conclusions seem justified:

1. The contact angle of water on bituminous emulsion and silicone water-resistant coatings is influenced by weathering processes. This fact may be important to the serviceability of the material.

2. Considerable differences exist among various materials with respect to their susceptibility to change of contact angle with water through weathering.

3. Coal-tar emulsions may be more susceptible than asphalt emulsions to harmful decreases of contact angle with water.

4. Immersion in water lowers the contact angle of water on bituminous emulsion coatings but subsequent drying restores the previous high value. For this reason, water should be drained from coatings as soon as possible.

5. Clay-type asphalt emulsion coatings seem to be surface-roughened by weathering processes.

6. The contact angle of water on silicone films is lowered by weathering processes.

ACKNOWLEDGEMENTS

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Advance Report of Committee 7—Wood Bridges and Trestles

Assignment 4

Methods of Fireproofing Wood Bridges and Trestles, Including Fire-retardant Paints

Collaborating with Committees 6 and 17 and with the Fire Protection and Insurance Section, AAR

B. E. Daniels (chairman, subcommittee), W. W. Boyer, D. J. Engle, W. A. Genereux, R. E. Grieder, J. A. Gustafson, R. E. Jacobus, J. V. Johnston, W. D. Keeney, J. R. Kelly, A. L. Leach, W. B. MacKenzie, F. W. Madison, F. W. Markwardt, E. A. Matney, J. W. N. Mays.

This is a progress report, submitted as information, on an investigation evaluating the contribution toward self-extinguishment of fires made by a fire inhibitor incorporated into the conventional pressure treating process. This study is being conducted for your committee at the AAR Research Center by the Engineering Division research staff. The investigation is being carried out by Seymour K. Coburn, research chemist, assisted by Kermit J. Morris, Jr., chemist, and John Anderson, technician, under the general direction of G. M. Magee, director of engineering research.

Effect of a Proprietary Fire-inhibiting Substance on the Flammability of Treated Southern Yellow Pine

DIGEST

The protection of wood bridges and trestles against fire may be attempted either before or after their construction. The wood may be treated with a fire-inhibiting composition before it is used in a structure, or it may be covered by a fire-retardant coating after it is in service. Fire prevention by the application of fire-retardant coatings to structures has been investigated for many years. Similarly, the impregnation of wood with water-borne fire-inhibiting chemicals has been employed extensively. Contemporary interest in the use of oil-soluble fire-inhibiting compounds incorporated in creosote wood-preservative solutions indicated the desirability of examining at least one such substance as a method of fireproofing, and this report covers this phase of the investigation.

A proprietary organic phosphorus-containing compound, soluble in oils and insoluble in water, was added to creosote, creosote–coal tar and creosote–petroleum solutions in the proportion of 13.5 percent by weight. Southern yellow pine timber, of nominal 2 by 6 by 18 in dimensions, was pressure-treated with the preservative solutions, with and without the fire-inhibiting additive, at the rate of 30 lb per cu ft, and ignited in a fire test apparatus for ignition periods of 1.5, 3, 5 and 7.5 min. The effect of mass was observed by the ignition of specimens consisting of a few pairs of 2- by 6- by 18-in boards bolted together. Temperature gradients, weight loss, self-combustion time and char depth served as criteria for evaluation of the mitigation of fire damage by the additive.

The results of the investigation show that addition of the fire-inhibiting compound into creosote and creosote–coal tar solutions confers a fire-quenching property to wood treated with the mixtures. The inhibitor did not appear to contribute any beneficial property to the creosote–petroleum solution. Timbers of relatively narrow cross section,

treated with a creosote–petroleum solution containing the additive, tend to suffer considerable char formation and delamination when exposed to vigorous fires of relatively long duration (more than 5 min ignition). This type of destruction does not occur in larger timbers because their greater mass prevents local heat buildup which, in turn, promotes the dehydrating char-producing chemical reaction responsible for the fire-inhibiting effect. When the larger, bolted specimens were burned, the magnitude of their weight loss and temperature development was reduced proportionately.

Since relatively small specimens were used in these procedures, one must remember that these data are unquestionably valid only for timber of the specified cross-sectional dimensions. Application of the results to larger timber must be done by careful inference. It should also be noted that each treated board upon which these observations were based contained a high concentration of treating solution distributed throughout the entire specimen, simulating the concentration found in the sapwood portion of piling. Furthermore, the effects of the direction of wood grain or width of annual rings on the delamination phenomenon could not be controlled during these experiments.

Additional investigation, with modification or elimination of the variables of solution retention and wood structure, conceivably could offer replies to some of the questions or objections posed by these observations while yielding information concerning the behavior of the additive under other conditions.

A. INTRODUCTION

The art and science of wood preserving has made an invaluable contribution to the railroad industry, probably as worthy as that made by the diesel engine. However, the wood-preserving industry, concerned as it is with a natural material, has not perfected its product with respect to its ability to resist fire, just as the diesel engine manufacturer has not completely overcome the problems of corrosion and fatigue of some of the structural and functional members comprising the finished product.

The destructive effects of fire still face man. Fire protection and insurance records of the Association of American Railroads indicate that losses due to bridge fires originating from a variety of causes reach a figure of $1,000,000 annually. So it is imperative that we learn more about the fundamentals relating to the generation, propagation and extinguishment of fire.

B. OBJECTIVE

One effort to mitigate the damage to treated timber srtuctures due to fires resulting from fusees, brake-shoe slivers, and brush and tumbleweeds is to utilize fire-retardant coatings. Previous studies by Coburn and Morris (1,2)* describe the behavior of a number of proprietary compositions when subjected to a series of fire and weathering tests, and develop basic information concerning the burning characteristics of treated timber. One of the reports (2) presents detailed information concerning the behavior of test specimens of southern yellow pine (nominal 2 by 6 by 18 in, S4S, Grade B & Better timber) in a fire-test cabinet. The purpose of these studies was to make possible the writing of a satisfactory specification covering the performance of fire-retardant coating materials.

The present approach toward minimizing damage to treated timber by fire is to incorporate into the conventional preservative solutions certain compounds which will function as fire inhibitors.

* Numbers in parenthesis refer to references in the Bibliography at end of report.

C. GENERAL DISCUSSION

In 1956 the first correlation conference on the subject of fire research was held in Washington, D. C., under the joint auspices of the National Academy of Sciences and the National Research Council at the behest and with the financial support of the Federal Civil Defense Administration (3). Here, for the first time, was presented a fairly complete survey of the practical and theoretical progress being made in the art and science of fire fighting.

Some of the authors pointed out that it often was impossible during the course of fighting a fire to upset the trinity of combustible substrate, air, and heat energy. Early investigators, probably our great grandmothers a dozen-fold removed, learned of the efficacy of throwing salt on a spreading cooking-grease fire. Careful study has shown that all salts are not equally effective. The universally used salt for dry-powder extinguishers is sodium bicarbonate, triggered by a cartridge of compressed carbon dioxide or nitrogen.

Thomas and Hochwalt (4), after evaluating 47 alkali metal salts, found that potassium chloride was 15 times more effective than lithium chloride in quenching a gasoline flame and, after testing every element capable of forming a water-soluble salt, found that only the alkali metals—lithium, sodium, potassium and cesium, in combination with oxygen such as in tartrate, chlorate, carbonate and the like—were effective extinguishing agents. Jorissen (5) found rock salt (sodium chloride) to be 17 times more effective than barium chloride for quenching a methane-air flame. It is evident from these independent observations that the physico-chemical mechanism for snuffing out a fire is indeed a complex phenomenon.

1. Discussion of Terms

It is necessary to clarify certain terms in order to avoid later confusion. The term "burning" is used in those instances where the rapid combination of oxygen and cellulosic- or hydrocarbon-derived materials (such as creosote and its solutions) results in the production of light and heat. This is sometimes termed gas-phase oxidation since gases arise as thermal degradation products when either of the aforementioned substances is heated. The same act also is called combustion; and substances which burn, therefore, are combustible.

Some combustible substances are incapable of forming easily ignitable gaseous decomposition products and merely glow, but they can be consumed just as completely as those which flame vigorously. This is an example of solid gas oxidation. The last, and probably most important, term to be discussed is "inhibitor." The use of this term is familiar to most individuals. Lead tetraethyl is an inhibitor used to suppress knocking of gasoline and is present only in a few tenths of a percent. Automobile anti-freeze contains corrosion inhibitors. The anti-oxidant incorporated in the fat used to fry potato chips prevents the residual fat on the chips from becoming rancid and is another example of an inhibitor. All of these materials are characterized by the old cliche: "A little goes a long way."

2. Current Ideas Concerning the Mechanism of Burning

In seeking means for snuffing out fires once the igniting source is removed or exhausted, it becomes necessary to understand the basic mechanism of burning as well as the mechanism by which the substances used to extinguish fires operate. Compositions of matter which reduce the intensity of combustion can appropriately be termed fire inhibitors.

When selecting materials of this type it is necessary that their activity relate directly to the action taking place in the fire. For example, when a pure form of cellulose burns it produces ignitible gases while leaving a liquid tar-like material accompanied by some char. If the proportion of char to liquid residue and gases be reversed to give more char and less liquid, then the destructiveness of a cellulose fire might be reduced considerably. It was toward such an approach that this work was directed. For this investigation southern yellow pine was treated with the conventional preservative solutions, each of which incorporated the same fire-inhibiting substance.

D. EXPERIMENTAL MATERIALS AND EQUIPMENT USED

1. Fire-Test Cabinet

The equipment used for obtaining the fire-test data is essentially the same as that described in an earlier paper (2) and shown in Figs. 1a and b. The fire-test cabinet is a rectangular, insulated chamber built to accommodate a specimen as large as a nominal 4 by 6 by 18 in; however, the bulk of the specimens studied were nominally 2 in thick. Draft control is effected by adjustable louvers. Propane fuel gas is supplied to two pairs of burners at the rate of 0.4 cu ft per min. The burner pairs are 24 in long and fixed vertically to two opposite walls. The propane flames are soft and long, such as occur in burning tumbleweeds, and envelope the specimen completely.

2. Temperature-Recording Equipment

Modifications and improvements have been made in the methods for measuring and recording temperatures. The thermocouple unit now consists of a pair of chromel-alumel wires encased in ceramic insulation and surrounded with $\frac{1}{16}$-in outside diameter stainless-steel tubing, as shown in Fig. 2. The temperature recording apparatus is a Weston multiple-point recorder of the null balance type with a potentiometer circuit and automatic reference junction compensation. The temperature at each of four locations in the fire-test cabinet is indicated at 12-sec intervals on a continuously moving roll of chart paper.

3. Thermocouple Placement

Holes 0.096 in. in diameter and spaced ¼ in apart were drilled along the longitudinal midline of the broad surface of the test specimen, beginning 6¼ in from one end of the specimen. The depth of drilling was controlled by spacers placed between the drill bit and the specimen. The relative positions of the thermocouple junctions were as follows:

TABLE 1—THERMOCOUPLE LOCATIONS

Thermocouple Number	*Inches from Top of Specimen*	*Inches Below Surface*
1	6¼	½
2	6½	¼
3	6¾	On surface
4	6¾	1 in above surface

The interior thermocouples formerly were inserted in the specimens through the narrow edge and traversed a distance of $2\frac{13}{16}$ in to the midpoint of the specimen. By the present method of thermocouple placement the error imposed by drilling parallel or

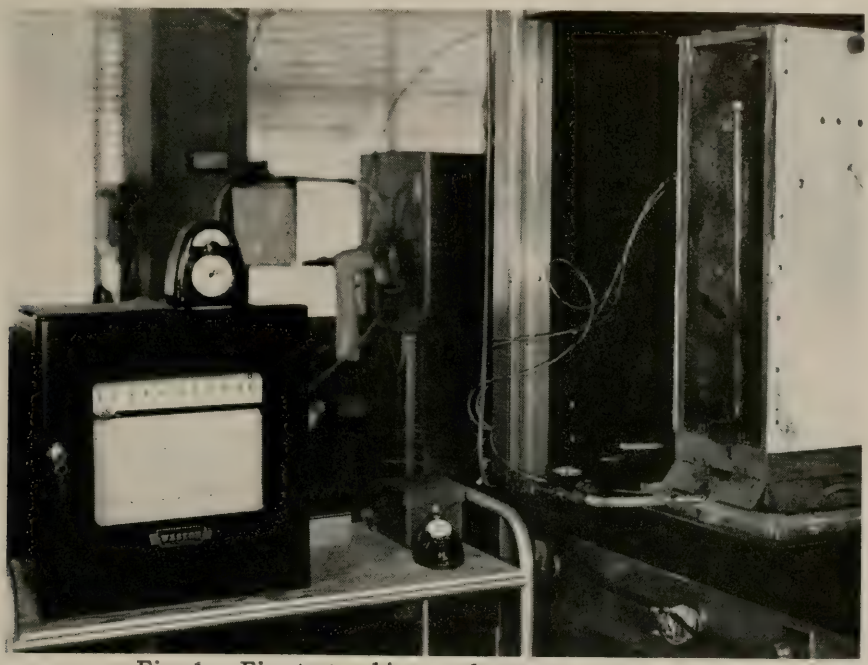


Fig. 1a—Fire-test cabinet and temperature recorder.

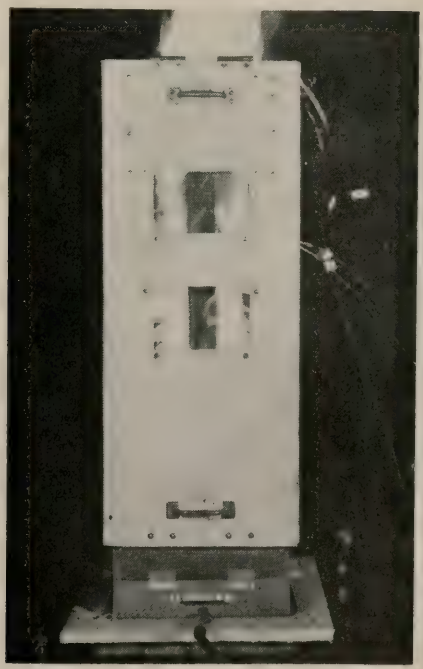


Fig. 1b—Burning specimen in fire-test cabinet.

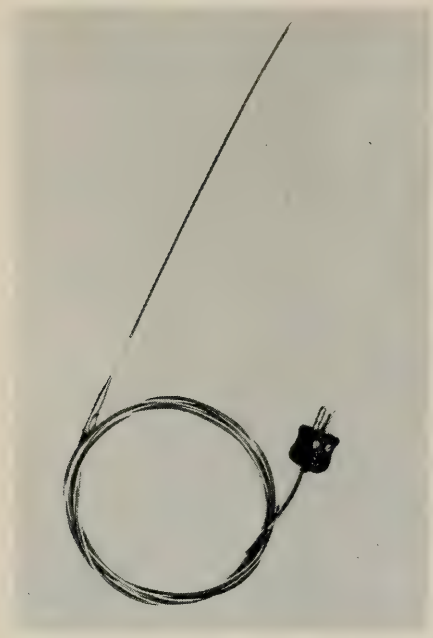


Fig. 2—Stainless-steel-sheathed thermocouple.

partially parallel to the grain of the wood was eliminated. Also, a condition was created whereby a much longer length of the thermocouples, beginning with the measuring junction, were positioned near the same location within the specimen, thus ensuring a more representative reading of the actual temperatures developed.

With respect to the reliability of temperature data, the four thermocouples faithfully record whatever temperatures develop during the course of a test. However, when the igniting flames are extinguished and the cabinet begins to cool, the internally located thermocouples at the ½-in and ¼-in depths are giving a more accurate over-all picture of the resultant thermal activity than the surface thermocouple, which may or may not be influenced by small flames occurring on the surface in its immediate vicinity.

4. Accelerated Weathering Test

An Atlas Single Arc Weather-O-Meter was used to carry out accelerated exposure tests for a period of 1000 hr daily in 17-hr cycles. Pairs of similarly treated specimens were placed opposite one another on a revolving rack where they were subjected to ultra-violet light from a carbon arc. The surfaces facing the arc reached temperatures of 140 F, while the rear surfaces approched 110 F. A water spray was played on the broad surfaces of the specimens for 18 min out of each 2-hr period, lowering the cabinet temperature to 80 F. A daily 7-hr period of darkness and room temperature was imposed to reflect conditions similar to nightfall.

5. Materials Used

The timber used consisted of nominal 2 by 6 by 18 in long southern yellow pine boards (B & Btr., S4S). The preservatives included coal-tar creosote, a 70:30 creosote–

coal-tar solution and a 50:50 creosote–petroleum solution. The treatment of the wood was carried out at the Forest Products Laboratory under the direction of J. Oscar Blew, Jr., technologist.

The retention in every case was 30 lb per cu ft, simulating the concentration found in the sapwood portion of piling.

The fire-inhibiting additive was a proprietary material generally identified as an aromatic ester of phosphoric acid. The supplier advises that it possesses a water solubility of less than 10 ppm at 68 F, low volatility (boiling point near 800 F), and does not decompose and is chemically stable under treating-plant conditions.

E. WEIGHT LOSS SUSTAINED DURING FIRE TESTS

The value of weight-loss measurements as a criterion of destruction in small-scale fire tests has been evidenced often. Satisfactory measures of fire susceptibility have been obtained when tests were carried out to establish the relationships existing between such variables as preservative type, age of treated specimen, retention and duration of exposure to a flame source.

Before any quantitative data are considered, some of the terms used in subsequent tables and graphs are discussed below.

Ignition period is the time during which propane flames in the fire-test cabinet were impinging upon a test specimen.

Free-burning time is the interval following the extinguishment of the propane flames when combustion continues as a result of the burning wood and freely flowing preservative.

Weight loss, unscraped refers to the specimen weight after all flames have been extinguished.

Weight loss, scraped refers to the specimen weight after all char has been removed.

UNT relates to untreated timber specimens.

The letters *C, CT, CP* and *A* designate, respectively, solutions of creosote, creosote–coal tar, creosote–petroleum and the proprietary fire-inhibiting additive.

The symbols *pcf* and *psf* represent the terms pounds per cubic foot and pounds per square foot, respectively.

1. Reproducibility of Weight-Loss Measurements

Numerous timber specimens treated with the preservatives used in the earlier study (2) have been evaluated repeatedly in the fire-test cabinet. Weight-loss measurements from such tests provide both a base for comparative testing of similarly treated wood and a measure of the reliability of the test.

In subjecting over 50 specimens to 5-min ignition periods in the fire-test cabinet, the maximum and minimum deviations obtained ranged from 3.1 to 0.7, respectively, for specimens whose weight loss varied from 47 to 26 percent. This is indicative of the reproducibility of the experimental data.

Recently two groups of treated specimens were burned with a one-year interval between tests. The first group was allowed to age at ambient indoor temperatures and relative humidity for three years prior to burning; the second group aged four years before burning. The specimens consisted of southern yellow pine treated with creosote, a 60:40 creosote–coal-tar solution and a 50:50 creosote–petroleum solution. The average

weight loss suffered by the two groups of specimens (15 per group), after a 5-min ignition period followed by 30 min of free-burning time prior to extinguishment, is shown in Table 3.

TABLE 3—WEIGHT LOSS PERCENT SUFFERED BY AGED SPECIMENS

Treatment	*Retention (Lb per Cu Ft)*	*Ignition Period (Minutes)*	*Weight Loss Percent*	
			Age—3 Years	*Age—4 Years*
Creosote	30	5	53	56
Creosote–coal-tar solution (60:40)	30	5	50	53
Creosote–petroleum solution (50:50)	30	5	38	37

It is clear from the tabulation of results in Table 3 that reproducible data can be obtained (see (2), Fig. 13, page 89). The rate of evaporation of volatile components of the preservatives had leveled off; a 33-percent increase in age resulted in no more than a minimal loss of preservative. Consequently, the difference in weight loss suffered by the three- and four-year-old specimens was insignificant.

2. Variation in Ignition Periods

The achievement of consistent weight-loss results lends confidence to the methods and allows for experimental variation in conditions in order to evaluate a number of fire-retardant coatings and the effectiveness of incorporation into the preservative of fire-inhibiting additives.

It was felt that variation in specimen size should be investigated from the standpoint of weight loss and internal temperature development from among similarly treated specimens when each was exposed to the same high-intensity fires for varying intervals of time. Test ignition periods would be fixed at 1.5, 3, 5, and 7.5 min, respectively. In each instance a free-burning interval of 30 min would be allowed before extinguishing any residual flames. In this way a clear picture would be developed for partially describing the behavior of treated specimens under a variety of field conditions.

3. Experimental Results Following 5-Min Ignition Period

The bulk of the experimental data is tabulated. However, in an effort to quickly orient the reader, bar graphs are used to introduce the weight loss data for 5- and 7.5-min ignition periods. Fig. 3 contains information describing the percent weight loss of the burned specimens before and after char removal.

After studying the data developed during a 5-min ignition period, it is seen that untreated wood loses about 35 percent of its weight. On the other hand, treated wood loses as much as 65 percent of its weight when impregnated with creosote. In terms of absolute weight loss, the untreated wood loses about 12 lb per cu ft while the treated wood loses up to 44 lb per cu ft—almost 4 times as much. When the specimen contains a creosote–coal-tar solution a 61-percent loss in weight occurs. Creosote–petroleum-treated timber under the same conditions loses only 44 percent of its weight. This relationship between preservative solutions has been found repeatedly during the course of our work, using timber treated at different times. The increased loss in weight over that of untreated timber is a joint loss resulting from the simultaneous burning of oil and wood and loss of moisture.

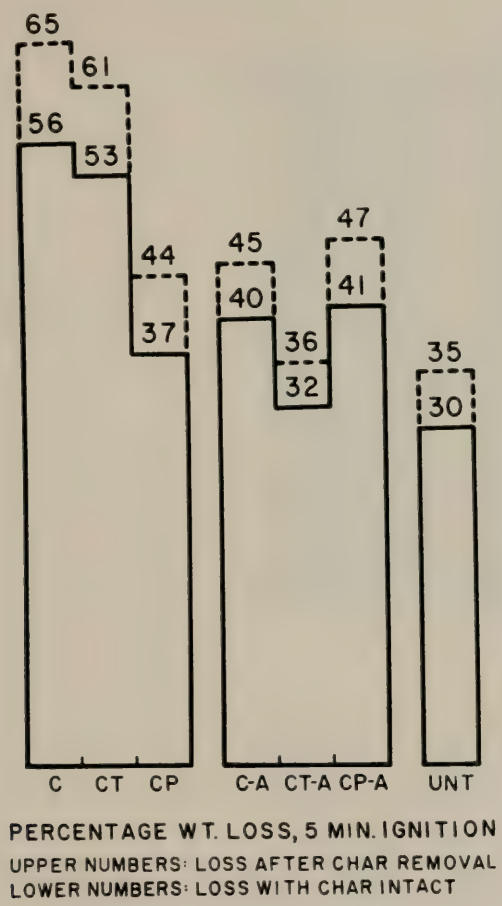


Fig. 3—Weight loss percent after 5-min ignition period.

On the other hand, when similarly treated timber specimens contain the additive in the amount of 13.5 percent by weight, considerably different results were obtained. Again referring to Fig. 3, it is noted that the loss in weight by the creosote–coal-tar treated specimens has dropped to 36 percent—much lower than the losses exhibited by specimens treated with the other solutions of preservative and additive. The creosote-treated timbers also benefited by the presence of the additive and reduced their vulnerability from 65 percent to 45 percent. However, the creosote–petroleum treated specimens derived little or no benefit and actually lost a bit more weight (47 percent) than when the additive had been omitted (44 percent). The percent char in every case can be estimated by substracting the figures above the solid bar from those above the dashed bar.

The appearance of an untreated specimen prior to and following exposure to a 5-min ignition period is shown in Fig. 4.

Fig. 4—Untreated timber before and after burning and char removed.

Figs. 6a, b and c picture a composite presentation of burned and char-freed specimens containing each of the preservatives in conjunction with the additive. The remainder of the quantitative data relating to the burning characteristics of the specimens, described in Fig. 3, is tabulated in Table 4.

TABLE 4—WEIGHT LOSSES INCURRED USING A 5-MIN IGNITION PERIOD

Preservative	*UNT*	*C*	*C-A*	*CT*	*CT-A*	*CP*	*CP-A*
Free-burning time (minutes)	2	30	20	30	15	19	23
Wt. loss scraped (percent)	35	65	45	61	36	44	47
Wt. loss unscraped (percent)	30	56	40	53	32	37	41
Wt. loss scraped (lb per cu ft)	11.6	43.9	30.4	38.2	25.4	28.5	32.7
Wt. loss unscraped (lb per cu ft)	9.8	37.8	27.2	32.7	22.1	24.1	28.2
Quantity of char (lb per cu ft)	1.8	6.1	3.2	5.5	3.3	4.4	4.5
Depths of char! (64ths in)	15	32	16	20	11.	16	14

It is evident from the results shown in Table 4 that the quantity and depth of char correlate quite well from the standpoint of a preservative-to-preservative relationship. A similar correlation seems to hold for preservatives with and without the additive. Other parallels exist in the data for scraped and unscraped test specimens. The decrease in free-burning time for specimens treated with the additive in creosote and in creosote–coal-tar solutions is amply demonstrated with a 50-percent reduction in free-burning time (from 30 to 20 min in the case of creosote–, and from 30 to 15 min in the case of creosote–coal-tar treated specimens.

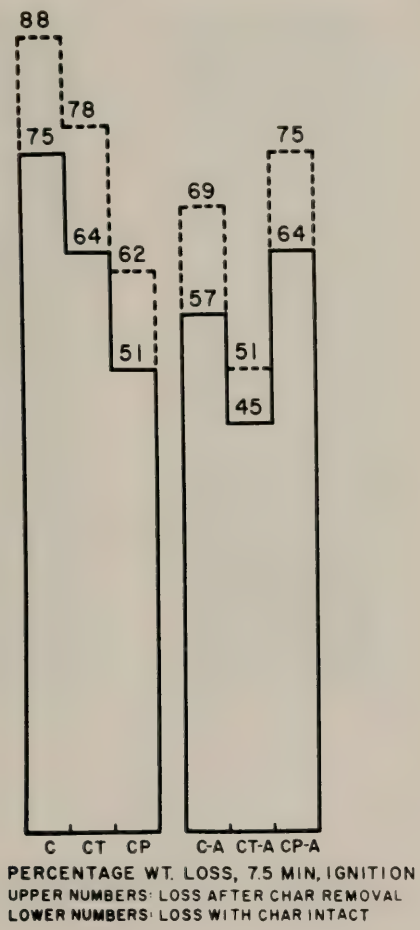


Fig. 5—Weight loss percent after 7.5-min ignition period.

4. Results from 7.5-Min Ignition Period

Weight-loss data are illustrated in Fig. 5 for specimens subjected to a 7.5-min ignition period. Relative results, in the absence of the additive, are similar to those noted in Fig. 3, with approximately a 50-percent increase in weight loss paralleling the 50-percent increase in exposure time to the flame source. The free-burning time, as generally practiced, was restricted to 30 min.

As a result of the large increase in exposure time, an increase in weight loss might be anticipated. That this happens is, of course, evident from the data. Nevertheless, the incorporation of the additive helped to minimize the destruction undergrone by the creosote- and creosote–coal-tar treated specimens. What is somewhat unusual was the accelerated burning rate which the presence of the additive imposed on timbers treated with the creosote–petroleum solution.

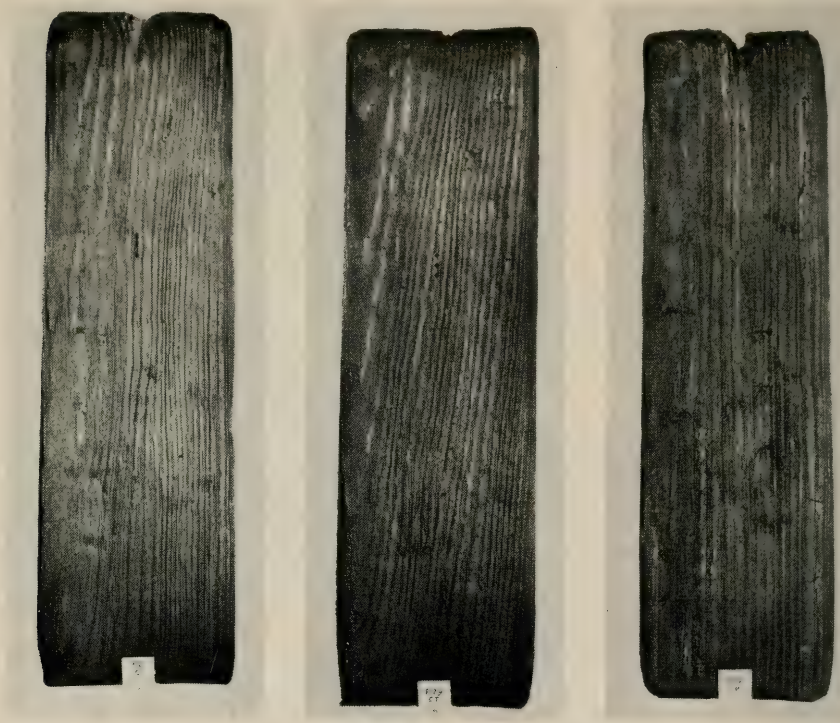


Fig. 6a (left)—Scraped specimen treated with a creosote solution of the additive.

Fig. 6b (center)—Scraped specimen treated with a creosote–coal tar solution of the additive.

Fig. 6c (right)—Scraped specimen containing a creosote–petroleum solution of the additive.

5. Effect of Specimen Size on Weight Loss, Using 7.5-Min Ignition Period

It is common experience that the surface dimensions and shape of a combustible object affect its ease of ignition and ability to propagate combustion. Although the nominal 2- by 6- by 18-in specimen was used to establish the bulk of these and earlier data, it was considered necessary to develop additional information by burning specimens of larger size.

Many factors influenced the choice of the present specimen size. Among the most important was the relationship existing between mass, volume and thickness. Since it was considered neither feasible, nor necessary, to exhaustively conduct verification experiments with a variety of specimen sizes during the evaluation of a single fire-inhibiting additive, a doubling in thickness of the present specimen was resorted to by merely bolting together two regular test timbers. This action resulted in specimens whose mass and volume increased by 100 percent while the surface area increased only

by 25 percent. The use of the same ignition periods for the nominal 4- by 6- by 18-in bolted specimens, as used for smaller specimens, introduces the same quantity of heat onto the broad surfaces facing the vertical burners. Table 5 contains the quantitative weight-loss relationships found after subjecting each of the specimens to a 7.5-min ignition period. Again, the retention of all specimens averaged 30 lb per cu ft.

TABLE 5—WEIGHT LOSSES INCURRED WITH REGULAR AND LARGE SPECIMENS, USING 7.5-MIN IGNITION PERIOD

Treatment	*UNT*	*C*	*C-A*	*Bolted C-A*	*CT*	*CT-A*	*CP*	*CP-A*	*Bolted CP*	*Bolted CP-A*
Free-burning time (minutes)	7	30	30	23	30	20	30	30	30	30
Wt. loss scraped (percent)	57	88	69	36	78	51	62	75	43	45
Wt. loss unscraped (percent)	45	75	57	32	64	45	51	64	35	39
Wt. loss scraped (lb per cu ft)	21.2	57.4	46.5	23.9	48.9	35.2	40.3	52.8	27.7	30.2
Wt. loss unscraped (lb per cu ft)	16.8	49.3	39.3	21.3	40.5	30.8	33.3	44.6	22.2	26.3
Quantity of char (lb per cu ft)	4.4	8.1	7.2	2.6	8.4	4.4	7.0	8.2	5.5	3.9
Quantity of char (lb per sq ft)	0.21	0.38	0.31	0.21	0.40	0.21	0.33	0.38	0.42	0.32
Depth of char (64ths in)	17	43	29	.....	39	17	34	37	11	13

From a consideration of the data in Table 5 and Fig. 5, numerous correlations and relationships are evident. Beginning with free-burning time, it is apparent that the fires were severe enough to cause continued burning up to the 30-min cutoff point, at which time all residual flames had to be extinguished. With the exception of the creosote–coal-tar–additive-containing specimens and the larger bolted specimens, considerable weight was lost in each group. The specimens treated with the creosote–petroleum–additive solution suffered the greatest loss in weight. This particular pattern was observed in all subsequent tests with a change of ignition period.

The bolted specimens performed in the manner anticipated for larger structures—namely, decreased weight loss, lower quantity of char production, lower depth of char and, in general, a slower rate of combustion.

Another observation points up the fact that incorporation of the additive with the creosote–petroleum solution in the larger specimen resulted in a 50-percent reduction in the quantity of char produced, 100—(3.9 x 100/8.2), as compared to those specimens in which the additive was omitted. This suggests that increasing the specimen size and incorporating the additive with creosote ought likewise to reduce char production. That this takes place, and to the extent of some 68 percent, is evident from the following calculation: 100—(2.6 x 100/8.1).

Additional evidence for the unique contribution made by the additive can be seen in the ratio existing between untreated and treated specimens in terms of the amount of char developed per square foot of area. Between creosote-treated specimens and those containing the additive there is an 18-percent reduction. However, on the basis of surface area, when the section is doubled by bolting together two timbers, the amount of char formed is reduced by 45 percent. In the case of creosote–coal-tar solutions, the presence of the additive in specimens of identical size results in a reduction of char by 50 percent. In the presence of a creosote-petroleum solution the additive is a negative

factor, since char production is increased by some 11.5 percent in the small specimen and is the same for each of the bolted specimens.

At this point a pictorial view of some of the specimens will bring out other aspects of the unique behavior demonstrated by creosote–petroleum-treated specimens. In accordance with the data developed in the weight loss study, Figs. 7a, b and c show that the least damaged specimens were those treated with a creosote–coal-tar–additive solution followed by the more extensively burned creosote–additive-treated specimens. The most extensively damaged specimens were those which had been impregnated with the creosote–petroleum–additive solution.

Severe delamination and separation of the springwood and summerwood bands occurred in each instance, reaching a maximum in the specimens treated with the creosote–petroleum–additive solution. Fig. 8 presents side and top views of the burned specimens, showing the delamination effect in detail.

When the cross section was doubled by bolting specimens together, the weight-loss data showed improved performance for the creosote–additive-treated specimens as well as for the creosote–petroleum–additive-treated timbers, but not to the same degree. Fig. 9a shows the bolted specimen prior to burning, while Fig. 9b shows the appearance of the specimen after the 7.5-min ignition period and the 30-min free-burning interval before removing the char. Figs. 10a and b show the external and internal appearance of the bolted specimens. It is clearly evident that delamination does not occur in the larger specimen.

6. Weight Losses Incurred in 3- and 1.5-Min Ignition Period Tests

In an effort to study the effect of the first few minutes of a high-intensity fire, tests were carried out using ignition periods of 3 and 1.5 min. The quantitative results for the various categories investigated are illustrated in Table 6 and 7, respectively.

Table 6—Weight Losses Incurred Using 3-Min Ignition Period

Treatment	*UNT*	*C*	*C-A*	*CT*	*CT-A*	*CP*	*CP-A*
Free-burning time (minutes)	5	30	14	29	12	15	19
Wt. loss scraped (percent)	28	55	29	44	26	32	34
Wt. loss unscraped (percent)	22	48	26	39	23	27	30
Wt. loss scraped (lb per cu ft)	8.7	38.9	20.8	31.5	18.6	19.8	24.1
Wt. loss unscraped (lb per cu ft)	6.8	34.2	18.2	28.1	16.0	17.2	21.3
Quantity of char (lb per cu ft)	1.9	4.7	2.6	3.4	2.6	2.6	2.8
Char depth (64ths in)	10	16	12	15	7	10	10

It is evident that reduction in weight loss, free-burning time, quantity of char produced and char depth took place to the extent of some 50 percent in the creosote–additive and creosote–coal-tar–additive-impregnated specimens. The creosote–petroleum–additive-treated timbers, however, suffered longer free-burning times and greater weight losses. Also, it is significant that a considerable amount of the weight losses recorded for speciments subjected to longer ignition periods (5 and 7.5 min) actually developed during the first few moments of exposure to the flames.

The same pattern of data will be observed in Table 7 as in Table 6, only with lower orders of magnitude.

Fig. 7a—Creosote-additive treatment after 7.5-min ignition period.

Fig. 7b—Creosote-coal tar-additive treatment after 7.5-min ignition period.

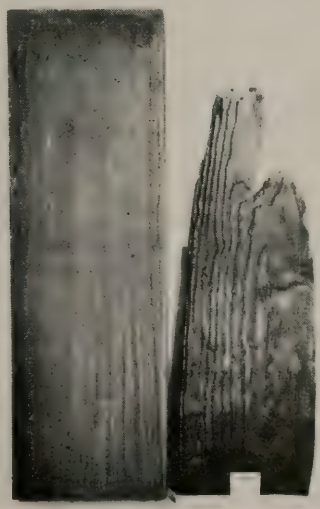


Fig. 7c—Creosote-petroleum-additive treatment after 7.5-min ignition period.

Fig. 8—Side and top views of delaminated specimens.

TABLE 7—WEIGHT LOSSES INCURRED USING 1.5-MIN IGNITION PERIOD

Treatment	*UNT*	*C*	*C-A*	*CT*	*CT-A*	*CP*	*CP-A*
Free-burning time (minutes)	12	27	11	21	8	14	11
Wt. loss scraped (percent)	14	33	14	26	12	19	19
Wt. loss unscraped (percent)	11	30	13	22	11	16	16
Wt. loss scraped (lb per cu ft)	4.9	22.6	10.3	17.7	8.3	12.9	13.3
Wt. loss unscraped (lb per cu ft)	3.8	20.6	9.3	15.0	7.4	10.9	11.6
Quantity of char (lb per cu ft)	1.1	2.0	1.0	2.7	0.9	2.0	1.7
Char depth (64ths in)	5	11	2	9	1	6	7

Once again, with only a minimum period of exposure to high temperatures, it is clearly seen that the presence of the additive exerts a beneficial quantitative influence on all specimens except those containing the creosote–petroleum–additive solution.

F. TEMPERATURE INVESTIGATIONS

1. Introduction

A graphical presentation of the temperatures developed during the course of the many tests carried out in the fire-test cabinet is a useful adjunct in evaluating the effectiveness of fire-inhibiting additives dissolved in the regular treating solutions.

The weight-loss data have brought forth a number of interesting facts, but in view

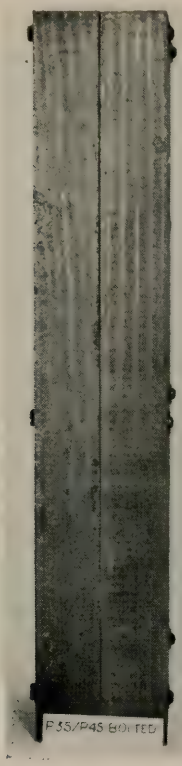


Fig. 9a—Bolted specimen.

Fig. 9b—Char-covered bolted specimen.

of the broad distilling range of creosote (300 to 700 F), it is necessary to have a knowledge of the temperatures reached on the surface and within a burning specimen in order to shed some light on the entire burning phenomenon. The discussion which follows attempts to relate such diverse factors as time of exposure to a fire source, specimen volume, mass, and retention.

2. Temperatures Developed Using 5-Min Ignition Period

a. Untreated Timber

Utilizing the revised method of thermocouple placement within a specimen, there is shown in Fig. 11 the extent of temperature rise during both the 5-min ignition period and the free-burning interval, which continued until the flaming specimen was self-extinguished. The cabinet temperature paralleled field conditions by reaching almost 1600 F. The surface temperature approximated 625 F, while a maximum of 400 F developed ¼ in beneath the surface. When the propane ignition flames were extinguished, both the cabinet and surface temperatures dropped rapidly. At the same time the internal temperatures continued to increase during the free-burning interval, indicating that heat transfer from the surface to the interior was taking place. This factor is quite important and should be kept in mind.

Fig. 10—Interior and exterior views of bolted test specimens after 7.5-min exposure period.

b. Creosote–Additive System

Examination of the time-temperature curves in Fig. 12 for specimens in the presence and absence of the additive reveals that lower temperatures (solid curves) developed in specimens containing the fire-inhibiting additive.

The contact in cabinet and surface temperatures as observed in both sets of curves (curves 1 and 2) is quite evident. This contrast is also exhibited by the magnitude of the internal temperatures (curves 3 and 4) which were influenced directly by the respective treatments.

These results help explain the relative duration of the respective free-burning periods and the amount of weight lost (tabulated in Fig. 3).

c. Creosote–Coal-Tar–Additive System

When a 70:30 creosote–coal-tar–additive system was investigated, results were obtained similar to those observed in the creosote–additive system. Definite reductions in both the temperatures reached and the free-burning time were observed. The data are presented in Fig. 13. Furthermore, a careful examination of the temperatures indicated by the solid curves of Figs. 12 and 13 will show them to be somewhat lower in the creosote–coal-tar–additive system than in the creosote–additive system. This is in keeping with the weight-loss data which indicated that timbers treated with the creosote–coal-tar–additive solution lost less weight than timbers treated with creosote or creosote–petroleum–additive solutions.

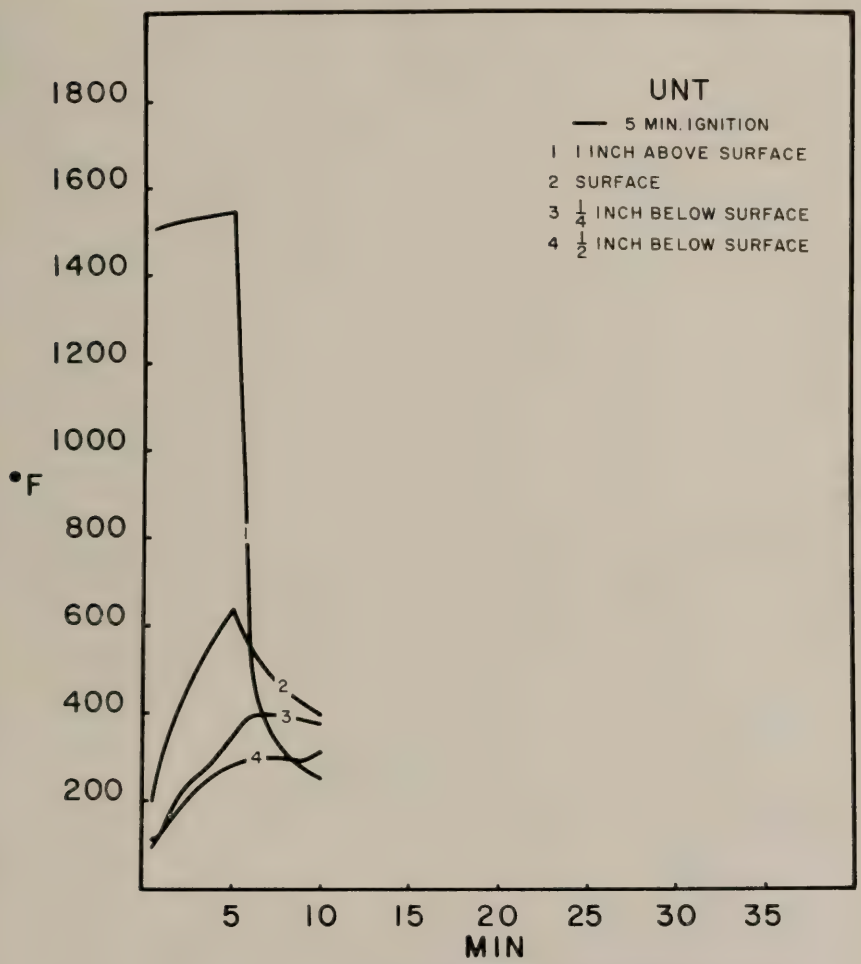


Fig. 11—Time-temperature data for untreated wood, using 5-min ignition period.

d. Creosote–Petroleum–Additive System

In the study conducted with specimens containing the 50:50 creosote–petroleum solution in the presence and absence of the additive, substantially no differences in temperatures were observed at any of the thermocouple locations, as evidenced from the data in Fig. 14.

e. Discussion

It is clear from all the time-temperature data that the additive, in combination with both creosote and creosote–coal tar solutions, made a positive contribution toward reducing the intensity and magnitude of the fires once the igniting source was removed

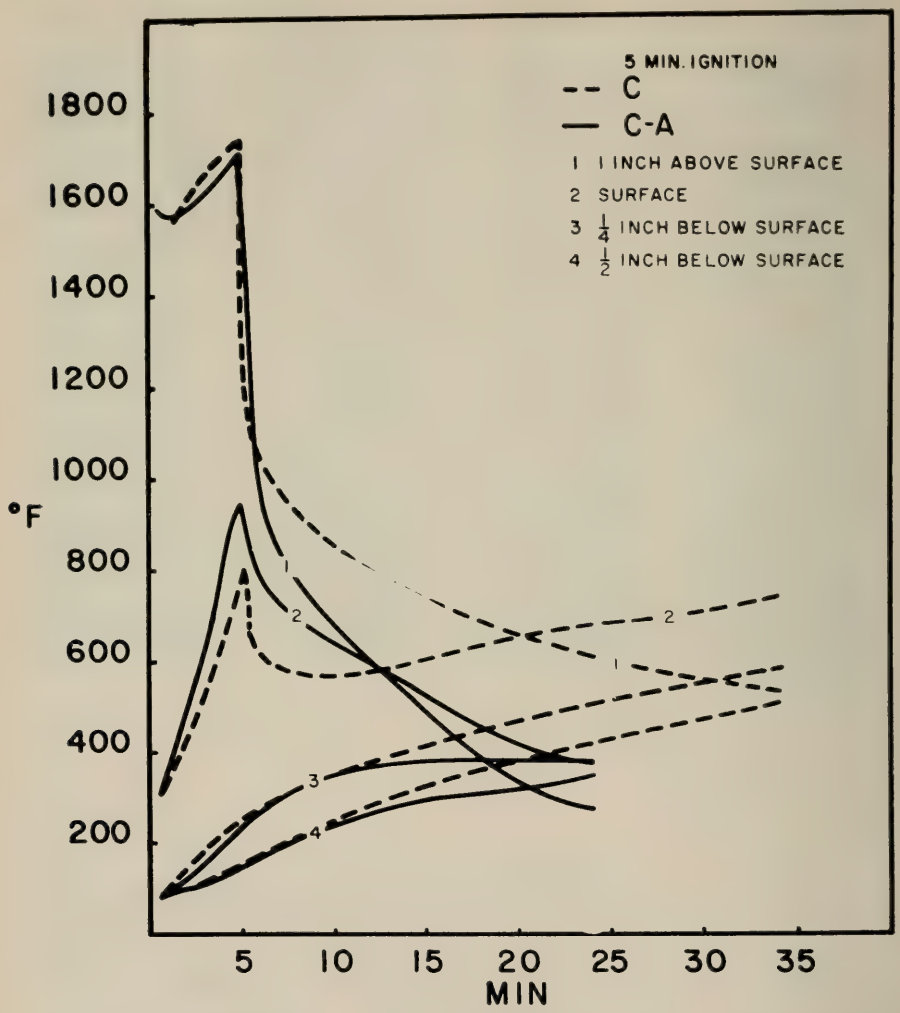


Fig. 12—Comparison of time–temperature data for creosote-treated specimens in the presence (C–A) and absence (C) of the additive (5-min ignition).

or consumed. What is surprisingly evident was the lack of effectiveness of the additive when incorporated in creosote–petroleum solutions .

It might be concluded from this series of experiments that the additive was selective in its inhibiting efficiency relative to this particular specimen size, retention, and time of exposure.

3. Temperatures Developed Using 7.5-Min Ignition Period

a. Creosote–Additive System

In order to extend the investigation and to take into account the possibility that a

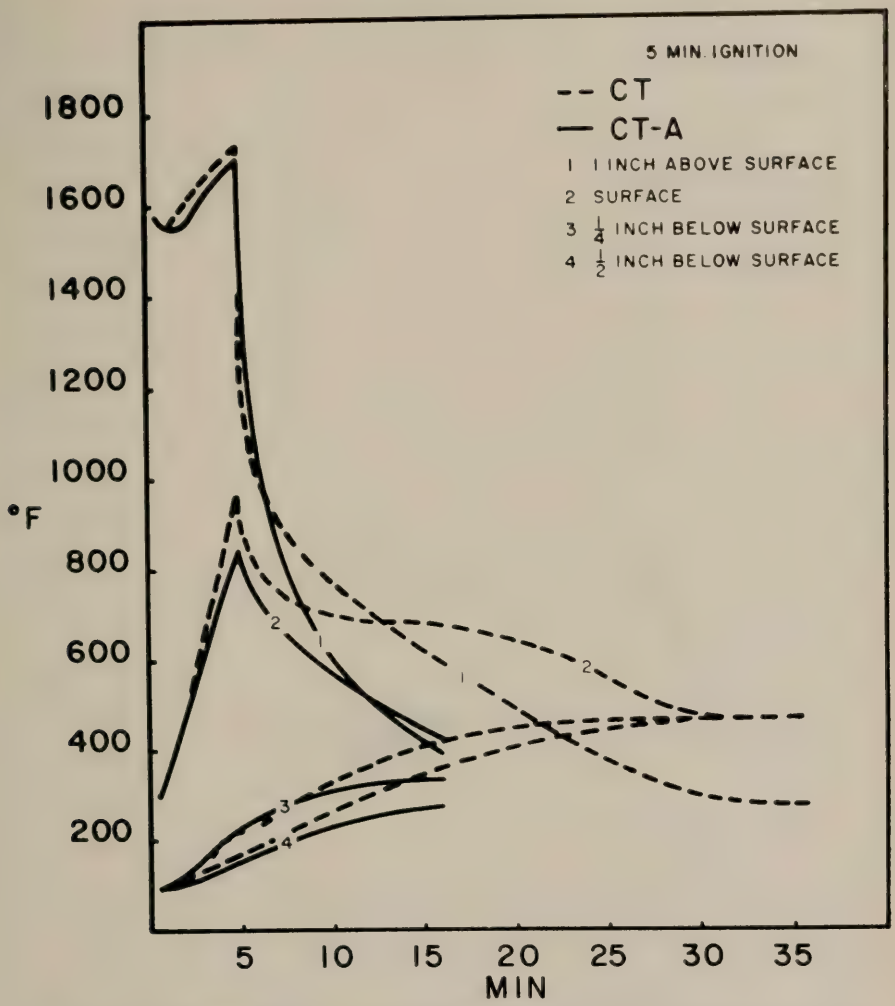


Fig. 13—Comparison of time-temperature data for creosote-coal tar-treated specimens in the presence (CT–A) and absence (CT) of the additive (5-min ignition).

high-ignition temperature source might last longer than 5 min, a 7.5-min ignition period was applied to the same-size specimens. Fig. 5 illustrates the results obtained and provides evidence that the additive exerts the moderating influence indicated by the weight-loss data.

b. Creosote–Coal-Tar–Additive System

In Fig. 16 are shown the comparable time–temperature curves for the creosote–coal-tar–additive system. It is quite apparent that the presence of the additive was responsible for the leveling off of the internal temperatures, leading to a reduction of

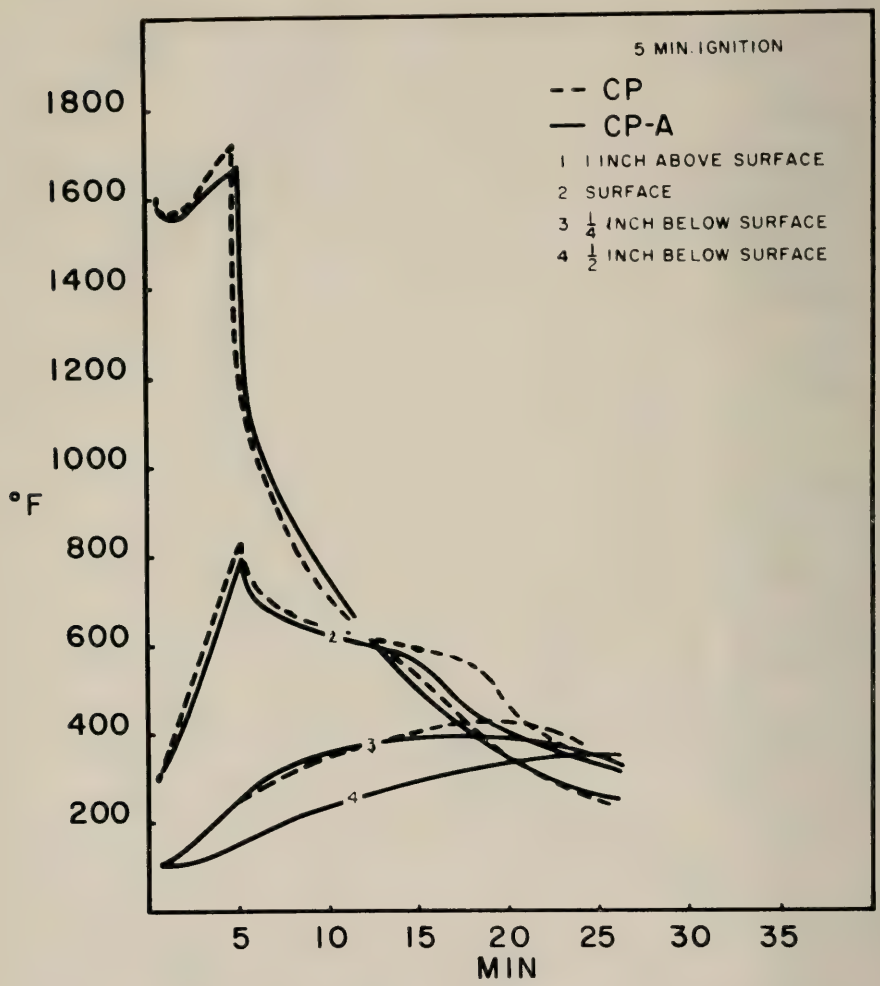


Fig. 14—Comparison of time–temperature data for creosote–petroleum-treated specimens in the presence (CP–A) and absence (CP) of the additive (5-min ignition).

outward flow of preservative, and thus minimizing the fuel supply and reducing the free-burning time.

c. Creosote–Petroleum–Additive System

Experimental data which help explain the anomalous results found in the weight-loss studies of this preservative system are shown in Fig. 17. It would appear from the slope of these curves that the presence of the additive serves to encourage the burning process, thus resulting in greater weight loss and a resultant longer free-burning period.

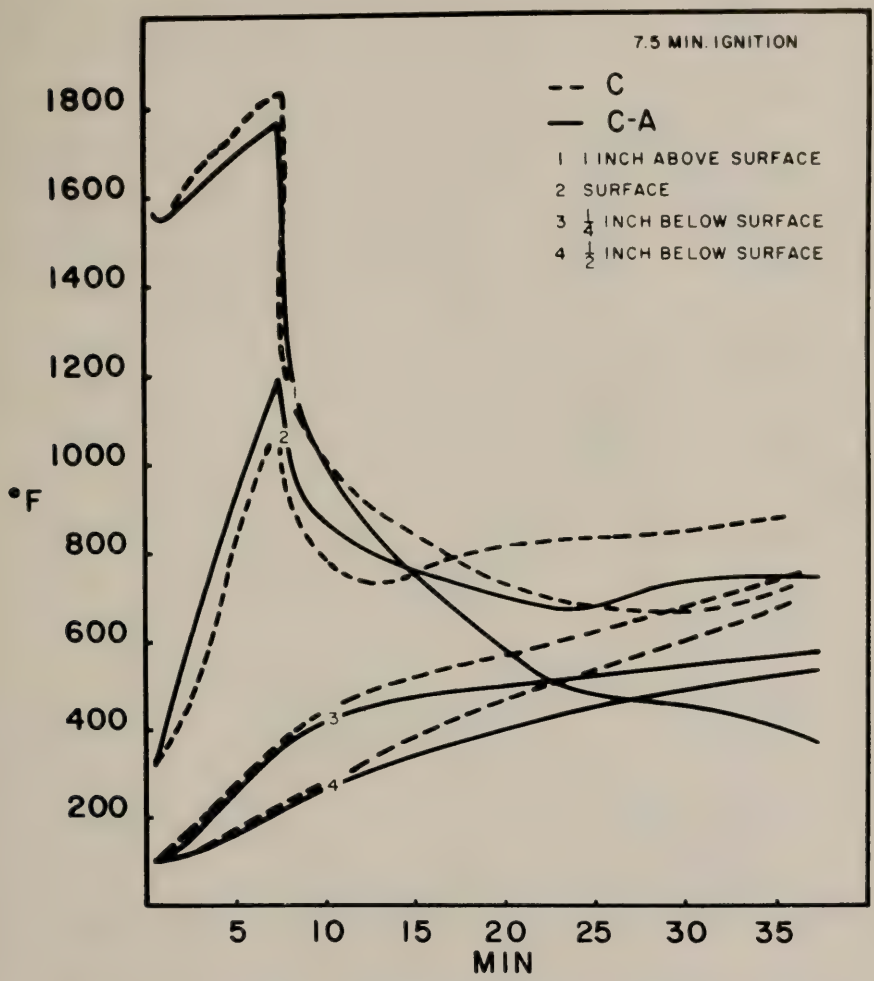


Fig. 15—Comparison of time–temperature data for cresote-treated specimens in the presence (C–A) and absence (C) of the additive (7.5-min ignition).

4. Temperatures Developed With Larger Specimens, Using 7.5-Min Ignition Period

a. Introduction

It was considered possible that the specimen size being used and the length of the ignition period together might be creating a severe condition. It was to explore this possibility that a group of experiments was designed using different ignition periods and larger specimens.

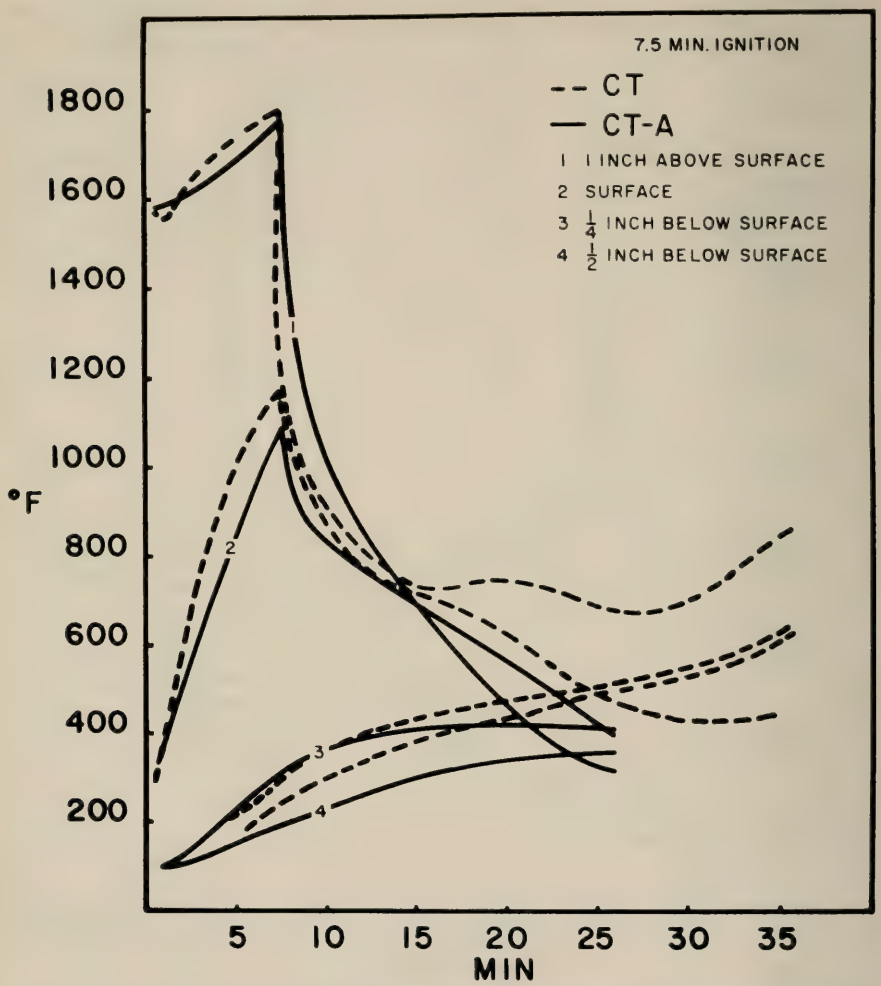


Fig. 16—Comparison of time–temperature data for creosote–coal tar treated specimens in the presence (CT–A) and absence (CT) of the additive (7.5-min ignition).

b. Creosote–Additive System

To evaluate the influence of increased dimension, pairs of treated specimens were bolted together. Several sets, with and without the additive, were burned in the fire-test cabinet, using a 7.5-min ignition period. The volume and mass of the test specimens thus were increased by 100 percent while the surface area was increased only by 25 percent. The average retention continued at 30 lb per cu ft.

Viewing the solid curves in Fig. 18 one can observe the temperature reduction effected by the presence of the additive, which parallels the results originally noted in the weight-loss studies of this system (see Table 5).

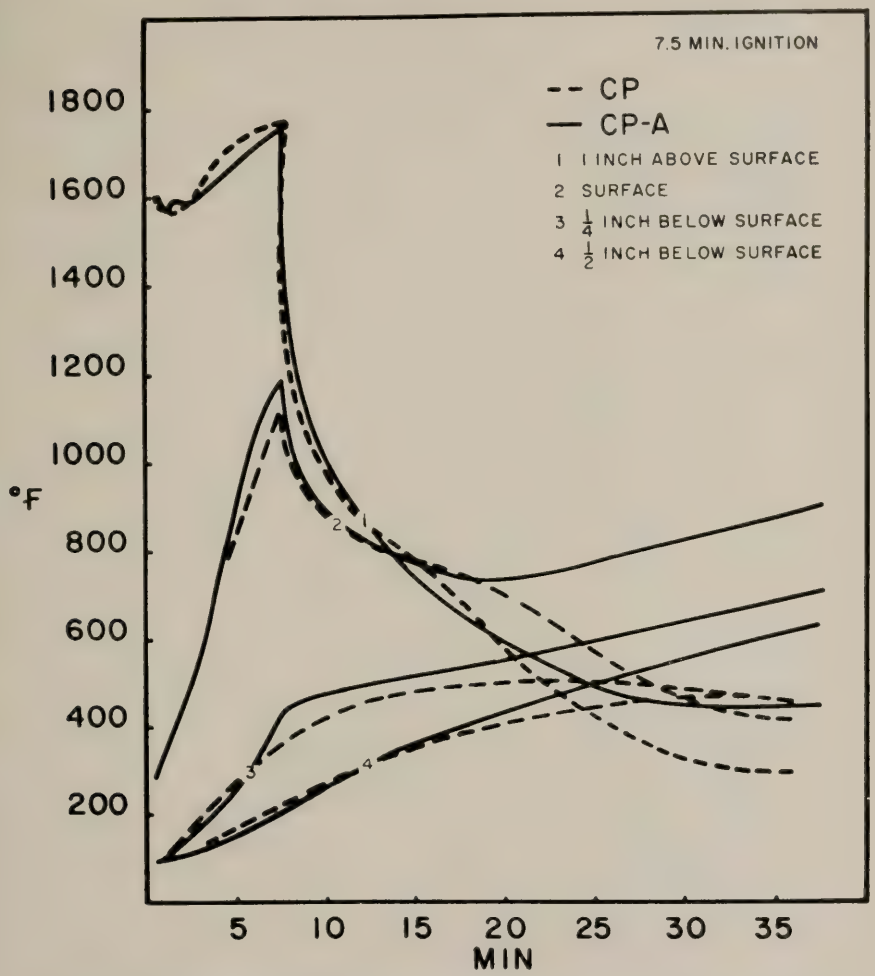


Fig. 17—Comparison of time–temperature data for creosote–petroleum-treated specimens in the presence (CP–A) and absence (CP) of the additive (7.5-min ignition).

c. Creosote–Petroleum–Additive System

The time–temperature data developed for the same type of bolted specimen, which had been treated with a creosote–petroleum–additive solution, was compared with a similar system in which the additive was omitted. The results of this study are presented in Fig. 19.

It is quite evident from a comparison of these time–temperature curves that a change in cross-sectional area altered conditions sufficiently so that the heat absorbed was dissipated over a greater mass of material, thus avoiding a temperature or heat buildup at localized areas near the surface. This allowed the additive to operate at

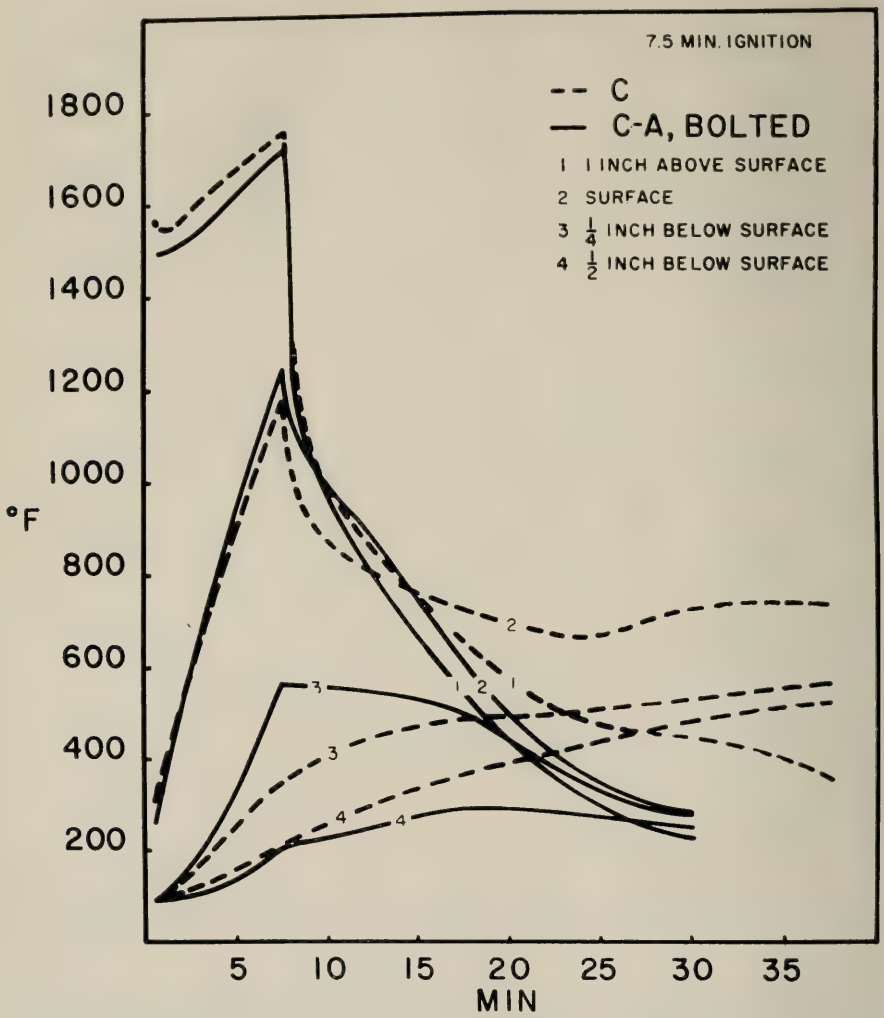


Fig. 18—Time–temperature data for bolted specimens treated with a creosote–additive solution.

greater efficiency. At the same time, a comparison of these data with those shown in Fig. 18 reveals the consistently greater effectiveness of the additive when present in creosote solutions than when incorporated in creosote–petroleum solutions.

d. Temperatures Developed in Specimens in the Absence of the Additive

In the absence of the additive, weight-loss studies repeatedly showed that creosote-treated specimens lost the most weight and creosote–petroleum-treated specimens lost the least weight, while creosote–coal-tar-treated timbers occupied an intermediate position. Figs. 20a, b and c show the time–temperature data developed during both the 5- and 7.5-min ignition periods.

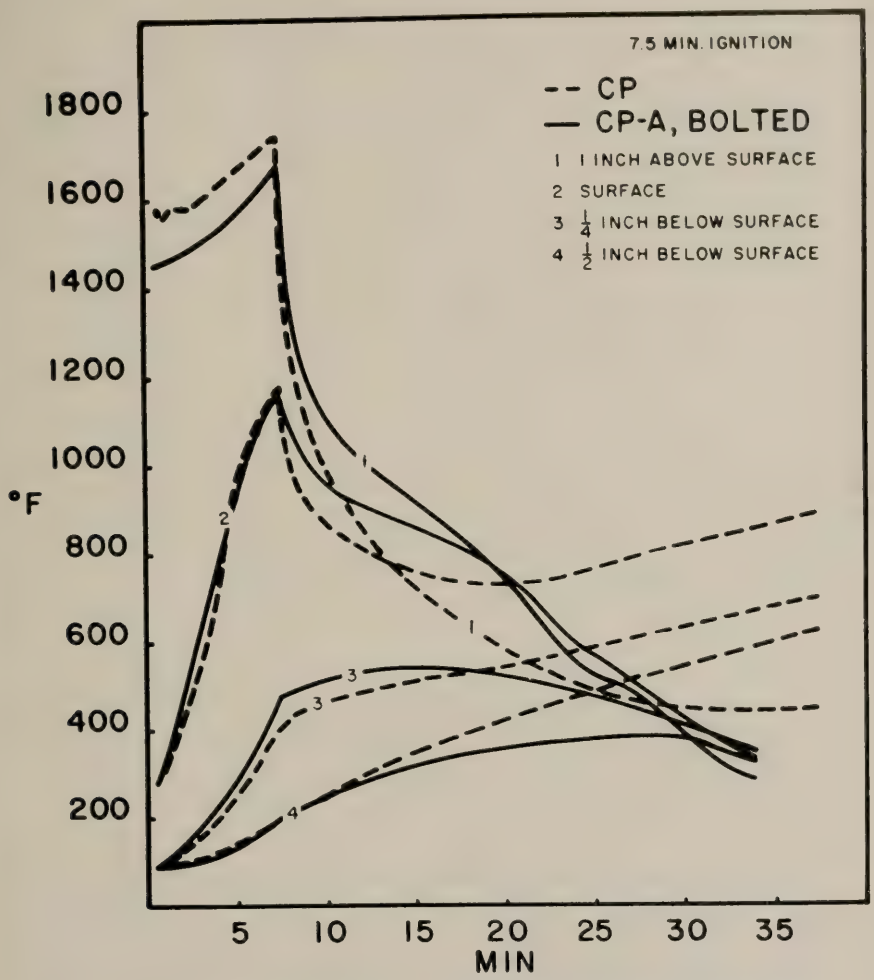


Fig. 19—Time–temperature data for bolted specimens treated with creosote–petroleum–additive solution.

By inspection of the dashed and solid curves one can observe the proportional increase in temperature with increased exposure time. Furthermore, by comparing the general slopes of the curves after the ignition source had been extinguished, one can further observe the decreasing temperatures developed relative to time for the respective preservative solutions.

G. RESULTS OBTAINED FROM BURNING WEATHERED SPECIMENS

As an adjunct to the regular burning tests, several test specimens were placed in an Atlas Single Arc Weather-O-Meter. The accelerated weathering test was initiated in an

effort to learn if there would be any significant evaporation or flow losses of preservative with a consequent loss in fire-inhibiting capacity. The results, though indicative, were not quantitative, since the number of samples used would not qualify for statistical validity, especially with a natural material such as wood. Nevertheless, the data proved to be of value and are shown in Table 8 as a composite of data drawn from other portions of the paper.

TABLE 8—WEIGHT LOSSES INCURRED BY BURNING REGULAR AND WEATHERED SPECIMENS

Preservative and Treatment	*Ignition Period (Minutes)*	*Free-Burning Time (Minutes)*	*Weight Loss (Percent)*	*Quantity of Char (Lb per Cu Ft)*
C	5	30	65	6.1
C-A	5	20	45	3.2
C-A (1000 hr)	5	15	38	2.7
C-A	7.5	30	69	7.2
C-A (1000 hr)	7.5	30	79	8.8
CT	5	30	61	5.5
CT-A	5	15	36	3.3
CT-A (1000 hr)	5	12	33	2.8
CP	5	19	44	4.4
CP-A	5	23	47	4.5
CP-A (1000 hr)	5	30	48	8.3

The most important conclusion that can be drawn from this experiment is that little or no loss in fire-inhibiting effect was noted in any of the specimens with the exception of the anomalously behaving specimens containing the creosote–petroleum–additive solution. During a 7.5-min ignition period there was a slight loss in the self-extinguishing ability of the specimen treated with the creosote–additive system.

H. SUMMARY OF CONCLUSIONS FROM EXPERIMENTAL WORK

The results of the weight-loss studies and temperature investigations show that incorporation of the additive or fire inhibitor confers a built-in fire-quenching action to timber treated with creosote and creosote–coal-tar solutions. When the same additive is mixed into creosote–petroleum solutions it appears to be non-operative, regardless of the length of the ignition period in the fire-test cabinet.

In every instance where the nominal 2 by 6 by 18 in long specimens were tested, creosote–coal-tar–additive-treated specimens lost the least weight, suffered less char formation and penetration, and developed the lowest internal temperatures recorded for the three preservative solutions. Specimens containing creosote and the inhibitor lost somewhat more weight, produced more char and greater depth of char, while developing slightly higher internal temperatures under the same test conditions. In both instances, however, the weight losses incurred, and the internal temperatures reached, were lower than when the inhibitor was omitted. Contrary to expectations the inhibitor did not appear to confer any beneficial properties to the creosote–petroleum solution. The loss in weight of specimens treated with this solution, as well as the quantity of char and depth of penetration, were substantially greater than that sustained by specimens containing the other preservative oils with the inhibitor.

In every instance when larger specimens were burned (through bolting two tim-

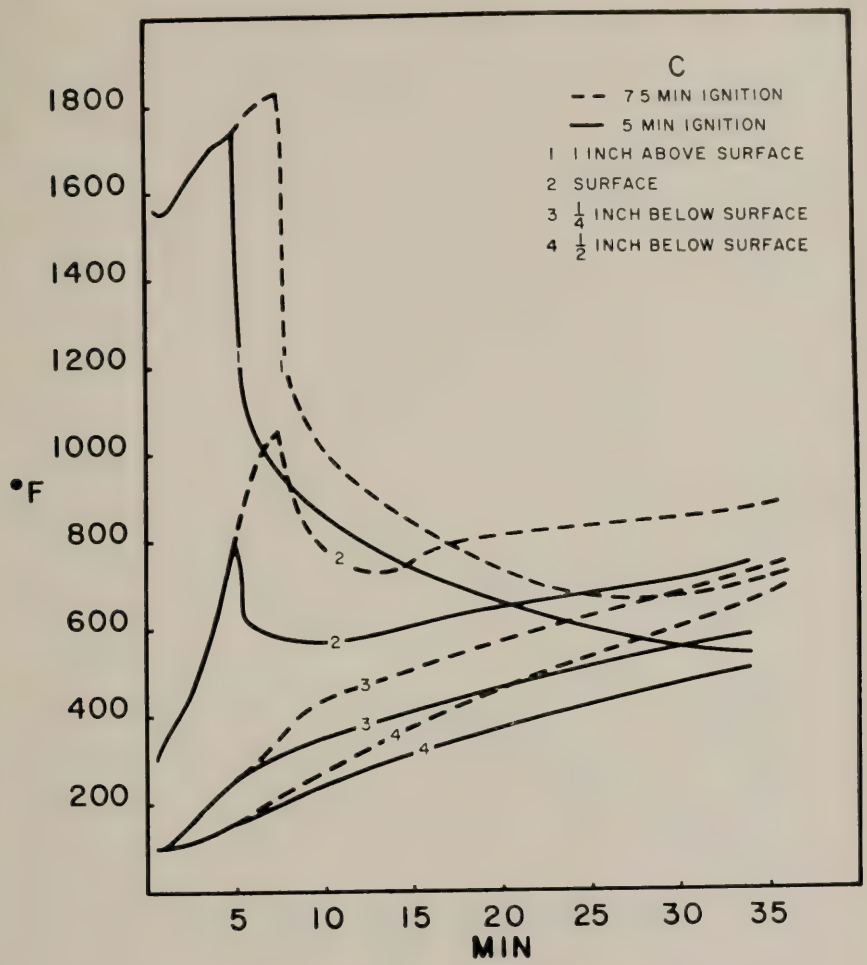


Fig. 20a—Time–temperature data for creosote–treated specimens, using 5- and 7.5-min exposure period.

bers together), both the temperatures developed and the magnitude of the weight losses were reduced. However, the relative flammability of the respective preservatives in terms of temperature and weight loss remained the same; i.e. creosote–petroleum–additive-treated specimens lost more weight and developed higher internal temperatures than the creosote–additive-treated specimens.

From an engineering design standpoint it is very important to recognize the significant differences existing in the behavior of the respective additive-containing treating solutions. Where timbers of relatively narrow dimensions or small cross-sectional area are involved it is likely they will suffer considerable weight loss, as well as severe delamination, when exposed to fires of relatively long duration if they are treated with

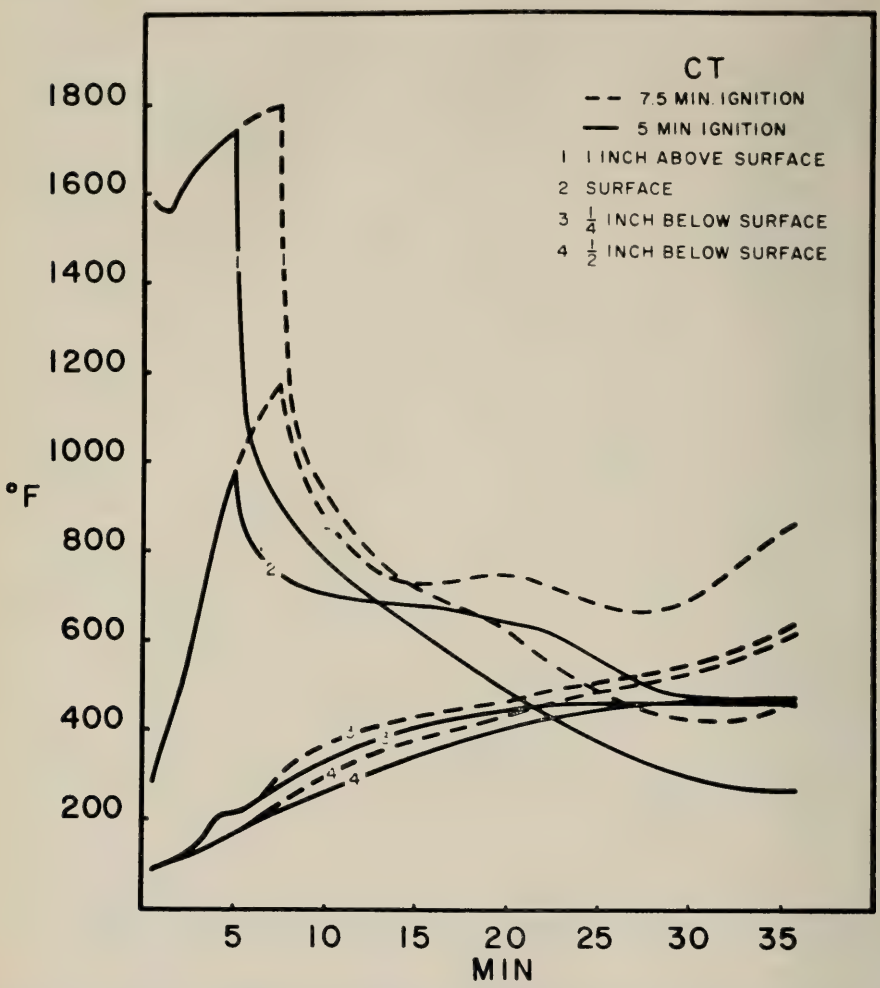


Fig. 20b—Time–temperature data for creosote–coal tar-treated specimens, using 5- and 7.5-min exposure period.

a creosote–petroleum solution containing the additive. This type of destruction does not occur in larger specimens because their greater mass prevents local heat buildup which, in turn, promotes the particular chemical reaction responsible for the flame-retarding effect. Where timbers are treated with creosote and creosote–coal-tar solutions the incorporation of the inhibitor definitely minimizes fire damage regardless of timber dimensions.

I. THEORETICAL ASPECTS OF FLAME INHIBITION

A brief summary of the many pieces of evidence which have been accumulated through the efforts of numerous investigators points to the fact that decomposition due

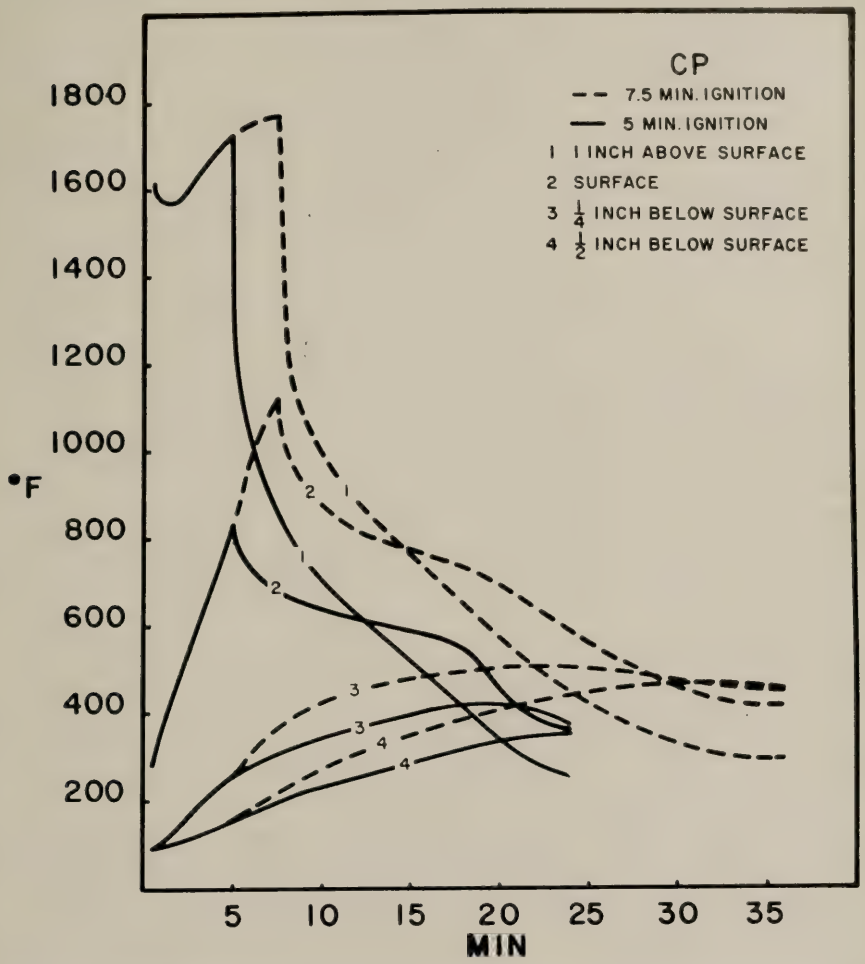
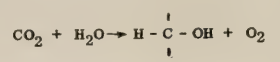


Fig. 20c—Time–temperature data for creosote–petroleum-treated specimens, using 5- and 7.5-min exposure period.

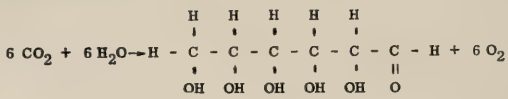
to the burning of cellulose as well as petroleum and coal-tar-derived substances results in broken molecules known as free radicals. Accompanying these fragments are free atoms of hydrogen and oxygen. Since it is an experimental fact that sodium will form compounds with hydrogen, oxygen and organic molecules to form hydrides, oxides and sodio-organic compounds, it becomes evident that throwing salt into a fire should serve to quench it. Experience proves that it does.

Another approach toward minimizing the extent of the burning of timber is to utilize strong dehydrating agents. The chemical structure of cellulose can be represented by the combination of one molecule of carbon dioxide and one molecule of water to produce one molecule of oxygen and one section of a molecule which polymerizes to

give sugar and eventually cellulose. This natural synthetic process is called photosynthesis and describes the growth of all cellulosic matter in nature. Symbolically the reaction can be represented in the following manner:



To form one of the breakdown products of cellulose, such as glucose, the representation would be as follows:



It is quite apparent that if some mechanism were available to split off the elements of water and convert the cellulose to a non-combustible form, such as charcoal, there would be little or nothing available for further combustion. Fortunately most of the substances known to act as flameproofing agents for wood and cotton textiles function by the degradation of cellulose. It has been postulated that a catalytic dehydration of cellulose results.

Whitmore in 1932 (6) first promulgated the unifying chemical principle which explained the nature of a large number of unusual chemical reactions through the mechanism of a "carbonium ion rearrangement." Substances such as aluminum chloride, zinc chloride, boron trichloride, sulfuric acid, phosphoric acid and phosphoric anhydride, better known as phosphorous pentoxide (P_2O_5), are capable of initiating these reactions and are called Lewis acids (able to accept a pair of electrons). A Lewis base makes the reactions possible since it offers a pair of electrons to satisfy the needs of a Lewis acid. Cellulose has a chemical structure which qualifies it as a Lewis base. A simple example of this type of reaction is one in which the familiar charcoal-rimmed hole develops in a cotton garment when a drop of sulfuric acid contacts it.

Early workers impregnated timber with a water solution of ammonium phosphate. This simple system provided some fire-retarding action; however, the phosphate was vulnerable to rain water and eventually would leach away. By introducing an organic component with the phosphate portion of the molecule, water insolubility was achieved. Experimental proof for this fact was obtained in our laboratory, and the data in Table 8 document the results.

Essentially the reaction is one in which the initial temperatures developed during the course of a tumblewood fire are sufficient to decompose the additive, which is a triphenyl phosphate derivative, to give the aggressive dehydrating agent, phosphorous pentoxide (P_2O_5). This substance reacts with all available free water and simultaneously strips off the elements H and OH from the cellulose to form water. When this is done the charcoal which results does nothing more than glow and burn out.

Some of the experimental results discussed earlier tend to bear out these contentions when creosote- and creosote–coal-tar-treated specimens are considered. When specimens treated with the creosote–petroleum–additive solution were subjected to a 7.5-min exposure period in the fire-test cabinet, they yielded a brittle, delaminated residue devoid of any structural strength. This result represents an extreme case of experimental verification of the mechanism of inhibition advanced by Schuyten and co-workers in their investigation of cotton (7). No detailed hypothesis is being advanced to account for this unusual action.

J. COMMENTS

After careful consideration of the varied experimental data developed as well as the published work of many investigators in allied chemical fields, it is felt that the introduction of compounds of the type mentioned earlier, as well as newer ones yet to be synthesized, represents one of the first new horizons in the more extensive utilization of treated timber.

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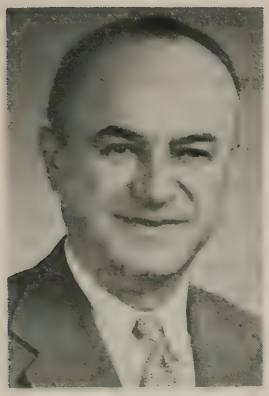
Report of Committee 16—Economics of Railway Location and Operation



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Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, presented as information ..... page 245

2. Effects of degrees of curvature on cost of track maintenance, collaborating with Committees 4 and 5.

   Committee previously submitted progress reports on phases of the subject, relating to ties, ballast, rail and other track material, and track laying and surfacing. Last-minute revisions of the expected final report precluded its completion, necessitating deferment until next year.

3. Determination of maintenance of way expenses for various traffic volumes, collaborating with Committee 11.

   Progress on assignment tied in with studies on Assignments 2 and 9, as well as other studies.

4. Potential applications of electronic computers to railway engineering and maintenance problems in research, design, inventory, etc., collaborating

with Committees 11 and 30, and informally with the Railway Systems and Procedures Association.

Questionnaire circulated to determine uses made of computers in solution of railway engineering problems with the thought in mind of compiling a library which would be available to all AREA members.

5. Methods of reducing time of freight cars between loading and unloading points, collaborating with Car Service Division, AAR, Signal Section, AAR, Operating–Transportation Division, AAR, and American Association of Railroad Superintendents.

   Extensive outline completed on subject which is to be followed in working up related portions of the overall assignment.

6. Economics of improved freight stations and facilities, collaborating with Committees 6 and 14, and with Freight Station Section, AAR.

   Final report, submitted as information ..... page 247

7. Engineering, maintenance and operating benefits to be derived from increased joint use of railway facilities, collaborating with Committees 11, 14 and 20.

   Progress report, submitted as information ..... page 250

8. Innovations in railway operations.

   Progress report, submitted as information ..... page 256

9. The effects of equated mileage and traffic tonnage as bases for allocation of available funds for maintenance of way operations on main and branch lines.

   Outline of subject being developed. Information being gathered to determine relationship between traffic and various kinds of maintenance programs affected.

10. Methods of minimizing cost of construction and maintenance of industry tracks to improve the competitive position of railways, collaborating with Committee 11 and with Law Department, AAR.

    An extensive report has been developed covering competitive influences of laws pertaining to industry sidings, construction and maintenance, out-of-pocket costs of construction and maintenance, methods of financing, and accounting practices. Report practically complete, except for moderate revisions suggested at last committee meeting. Subject to be completed for 1961.

11. Review of developments in new methods and modes of transport.
    Committee gathering data on developments of vehicles cushioned or supported by air streams underneath. Committee also considered review of mono-rail possibilities.

THE COMMITTEE ON ECONOMICS OF RAILWAY LOCATION AND OPERATION,
R. L. MILNER, *Chairman.*

AREA Bulletin 553, November 1959.

Report on Assignment 1

Revision of Manual

A. S. Lang (chairman, subcommittee), H. S. Bull, R. A. Gleason, C. A. James, H. P Morgan, T. C. Nordquist, J. P. Ray, George Rugge.

Your committee submits the following report of progress.

After extensive study and discussions, it has been decided that the present organization of the material in Chapter 16 of the Manual is no longer workable. The Chapter has been amended so often over the years that it no longer retains any logical structure and cannot, therefore, serve its intended purpose.

As a result, your committee intends to rewrite the entire Chapter, retaining such material as it can, revising other material where changes in railway practice indicate this is desirable, adding some new material, and putting the whole into a new organizational framework consistent with the nature of the subject matter covered.

To this end your committee has developed the new chapter outline shown below, on which comment, particularly as to completeness, is earnestly solicited.

DRAFT OUTLINE—CHAPTER 16 REVISION

Part 1—Railway Location

A. Basic Economic Considerations
   1. Location
   2. Economic plant
   3. Capital return formula
   4. Basic principles of location

B. Special Considerations
   1. Temporary construction
   2. Engine districts
   3. Ruling gradients
   4. Helper districts
   5. Balanced profiles
   6. Momentum gradients
   7. Compensation for curvature
   8. Grades and alinement through tunnels
   9. Passing sidings

C. Choice of Alinement
   1. General
   2. Distance
   3. Curvature
   4. Rise and fall
   5. Maximum gradients
   6. Economic comparisons

D. Relocation
   1. General
   2. Determination of operating expenses

Part 2—Motive Power

A. General
   1. Types of motive power
   2. Tractive effort

3. Horsepower
4. Acceleration
5. Adhesion
6. Locomotive capacity
7. Transmission efficiency
8. Performance factor
9. Locomotive classification

B. Electric Locomotives
1. Systems of electrification
2. Types of electric locomotives
3. Operating characteristics
4. Electric braking

C. Diesel–Electric Locomotives
1. General
2. Operating characteristics

D. Steam Locomotives
1. General
2. Operating characteristics

E. Other Types of Motive Power
1. Gas turbine-electric
2. Direct-drive diesel
3. Other (?).

Part 3—Train Performance

A. Types of Train Resistance
1. Level tangent resistances
2. Curve resistance
3. Grade resistance
4. Other resistance factors

B. Train-Resistance Formulas
1. Davis formula
2. Other formulas

C. Train Performance Calculations
1. Speed-time-distance method
2. Velocity profiles
3. Approximate methods

D. Other Evaluation Methods
1. Dynamometer car tests
2. Train performance simulation

E. Fuel Consumption
1. Steam locomotives
2. Electric locomotives
3. Diesel-electric locomotives
4. Other motive power
5. Approximate methods

Part 4—Railway Operation

A. Tonnage Ratings
1. Adjusted tonnage ratings
2. Correction factors
3. Other rating systems

B. Line Capacity
   1. Freight-train performance charts
   2. Effect of operating changes on capacity
   3. Approximate formulas for line capacity
C. Miscellaneous
   1. Cost of stopping and starting trains
   2. Through routing of trains
   3. Other (?)

Report on Assignment 6

Economics of Improved Freight Stations and Facilities

Collaborating with Committees 6 and 14, and with Freight Station Section, AAR

T. D. Wofford (chairman, subcommittee), R. A. Gleason, F. E. Gunning, H. C. Hutson, A. E. MacMillan, J. C. Martin, J. P. Maynard, M. B. Miller, R. E. Nichols, F. N. Nye, E. L. Russell, D. S. Sundel

This is a final report, submitted as information

Many improvements in freight stations have been developed and installed on American railroads in recent years. Among the more advanced features of recently improved facilities are such items as:

- Continuous chain conveyors
- Centralized checking centers
- Talk-back speakers
- Pneumatic tube systems
- Cranes for heavy loads and containers
- Mechanically controlled overhead doors
- Improved lighting
- Retractable cross platform bridges
- Enclosed steel-frame buildings
- Modern offices, locker rooms and lunch rooms
- Complete equipment–maintenance shops
- Concrete platforms and fireproof construction

A review of available statistics indicates that the Class I railroads in the United States originated in 1957 less than one-eighth the LCL tonnage handled in 1923. From 1923 to 1957 this traffic decreased from 44.3 million to 5.4 million tons, a reduction of 88 percent. The rate of decrease from 1949 to 1957 has averaged about 10 percent per year.

Studies by various roads indicate that certain LCL facilities which operated without loss on an out-of-pocket cost basis as recently as 1952 have since become unprofitable because of decreasing revenue coupled with rising operating cost. The trend in revenue freight originated is shown graphically on Chart 1. While the total tonnage of revenue freight originated by railroads has decreased since the peak in 1947, as indicated by the chart, the proportion of less-than-car-load tonnage has dropped at an even greater rate, which emphasises the railroads' loss of this important traffic. Determining influences includes both rate and service factors as well as the inroads of competitive modes of transportation.

On roads where the LCL service includes free pick-up and delivery, an even greater concern has arisen over the sharp decrease in revenue. The rising cost of supplying this service contributes materially to the problem of LCL revenues.

Because of the shrinking volume of LCL freight business, many roads have been inclined to postpone any large-scale investment in LCL facilities at this time. There are, nevertheless, circumstances under which sizeable improvements have been and can be

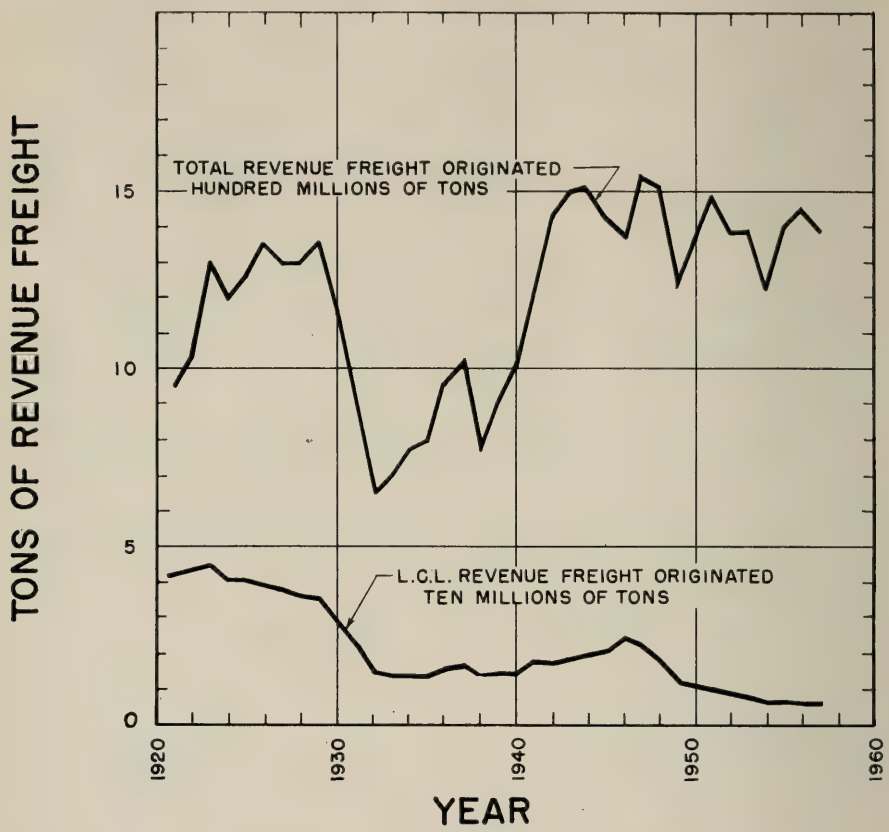

CHART 1
TONS OF REVENUE FREIGHT ORIGINATED
CLASS I RAILROADS IN UNITED STATES

economically justified. These have been restricted principally to major terminals where a reasonably consistent volume of business can be maintained and where the annual savings have been found sufficiently attractive to justify completely new and modern facilities. One or more of the following means to off-set the declining volume of LCL freight have been or may be used at various locations.

1. Consolidating break-bulk and transfer operations on system.
2. Consolidating existing houses where volume has decreased below economic operating levels.
3. Handling truck line freight operation together with rail traffic.
4. Accommodating freight forwarder and freight association operations together with railroad LCL and Railway Express operations.

Appreciable savings have been reported as a result of consolidating separate freight houses at one location, using existing facilities. Moves of this type usually result in a reduction of both office forces and freight handlers, as well as switching. While consolidations using existing facilities do not have all the advantages of new installations, the remodeling can frequently be done at low cost, often less than the first year's out-of-pocket savings. Additional benefits in some instances can be realized through leasing vacated space to other revenue-producing activities.

In addition to the operating features, other economic factors are often involved in decisions to construct new, or improve existing, LCL freight-handling facilities. These include such items as:

1. Urban redevelopment and land clearances.
2. Public improvements, such as expressways and toll roads.
3. Development of railroad property occupied by freight houses for private use, such as commercial buildings and parking lots.
4. Movement of railroad facilities to outlying areas in conjunction with construction of new yards and terminals.

In many instances LCL operations are conducted in houses that are obsolete and largely depreciated. While these structures have small recorded value remaining, they represent sizeable investments on a reproduction-cost-new basis. Unless their value as an operating facility can be established, there is seldom an opportunity to sell or otherwise dispose of the existing facility for a sufficient amount to justify construction of new facilities.

The economic justification for relocating freight houses from the downtown to outlying locations involves such factors as origination and destination of traffic handled, service required, effect on truck pick-up-and-delivery cost, and effect on switching and rail movement of cars. These factors are found to vary so widely with individual facilities that no general conclusion can be reached without detailed study. Many cities have imposed zoning restrictions on the erection of railroad freight facilities within corporate limits, and it is reasonable to expect that the trend in locating future new construction will be toward outlying areas.

Large, modern, freight-house facilities constructed in recent years have in several instances provided for 350,000 to 400,000 sq ft of space under cover. Such facilities involve large expenditures per square foot of working platform space because of the expensive complexity of equipment and office space required to secure the desired operating economy. Where entirely new facilities cannot be justified, remodeling of existing facilities can often be economically justified by adaptation of modern equipment to effect savings in high-labor-cost manual operations. There are examples of older houses where continuous chain conveyors, centralized checking centers and talk-back speakers have been installed with very satisfactory results. Modernization of existing facilities often can be limited to expenditures of modest proportions. Improvements averaging as low as $3 per sq ft of working platform space have been carried out with resultant annual savings of 30 percent or more of the cost. Experience indicates that the cost per ton for handling freight can be reduced at least 20 percent through the installation of modern equipment when the volume of business can be maintained at a reasonably constant level.

Despite the increased cost of labor, it has been possible at many freight stations to hold down the increasing cost of platform operations through the use of various mechanical devices and innovations. However, the station office expenses generally have been more difficult to control because of complicated tariffs, accounting and billing

features, and other factors which necessitate high clerical costs. While clerical expenses often can be reduced by use of modern equipment and systems, there is a great potential for simplification of station office procedures to effect additional economies.

Until the loss of LCL traffic is reversed, potential savings in operating cost and improvements in service are likely to be considered marginal, and available funds will be invested where the benefits are more certain. This is especially true in view of the large sums involved in making improvements in major terminals.

The growing use of containers and trailers on flat cars is causing a further reappraisal of the freight house in the over-all transportation picture. At this time, new aspects of containers and rail-trailer equipment and methods of operation are being explored to determine means of reducing damage and extra handling, facilitating movement and also lowering labor costs for handling LCL freight. The impact of these new developments will significantly influence the design and economics of future freight-station improvements.

Some interest has been manifested in the economics of joint LCL freight facilities to serve the consolidated operations of two or more roads in certain cities. Where the volume of business handled by individual roads on their own property has reached unprofitable levels, there appears to be considerable merit in a consolidated facility. Economies under such an arrangement may result where the combined volume is sufficient to justify a modern-type facility with efficient equipment for freight handling. Projected facilities of this type offer possibilities for savings through elimination of intra-city movement between freight houses, duplicate service to cities on other lines, combined agency forces, better utilization of labor, reduction in switching and reduced pick-up-and-delivery costs.

Report on Assignment 7

Engineering, Maintenance and Operating Benefits to be Derived from Increased Joint Use of Railway Facilities

Collaborating with Committees 11, 14 and 20

J. W. Barriger (chairman, subcommittee), C. H. Blackman, C. P. Blair, I. C. Brewer, R. M. Champion, Jr., B. Chappell, H. B. Christianson, Jr., S. B. Gill, J. E. Inman, T. D. Kern, R. B. Midkiff, H. P. Morgan, J. R. Nutter, F. J. Richter, E. L. Russell, K. A. Werden, H. L. Woldridge.

Your committee submits the following report as information and as an example of the benefits to be derived from the joint use of railway facilities.

This report covers the coordinated use of trackage by two railroads (which are identified as Railroad I and Railroad II), under the terms and conditions as hereinafter explained.

1. General Considerations

The following is an outline of the considerations adopted by Railroad I in determining the economy of maintenance and operation to be realized by coordinating parallel or duplicate trackage.

This particular railroad has been coordinating the use of railroad trackage and appurtenant facilities for some years on a "share-the-net-annual-savings basis."

When it is determined that it would be mutually advantageous to effect a coordination with another company, it is the usual practice to consider several methods of approach for preliminary study. The trackage and facilities to be abandoned as a result of coordination may be equal for the two companies or perhaps entirely by one com-

pany, depending upon the most favorable maintenance and operating savings to be obtained. After a plan has been selected each company prepares a detailed outline of the economic factors involved. (The trackage to become jointly owned or otherwise used on a tenancy basis is referred to as trackage of the Owner Company, and the other company is referred to as the User Company.)

a. Cost to Effect the Coordination

The User Company constructs and maintains the connections to the right-of-way line of the Owner Company, and the Owner Company constructs from right-of-way line to headblock, to effect each connection. Each company shares equally the cost of connections. This is usually handled by the constructing company billing one-half of its cost to the other company. These billing costs include labor and material additives, and where second-hand track materials are used, the unit prices are agreed upon by both companies.

b. Net Salvage of Trackage and Facilities to Be Abandoned

The net salvage is also shared equally by the two companies. The company obtaining the most net salvage, based on agreed market value, shares one-half the excess value with the other company in cash or materials if such materials are of the same standard for both companies. If the material is not of the same standard, a cash payment would be made for one-half the excess.

c. Net Annual Normalized Maintenance Savings

(1) After consideration is given to the normal labor force and material required for the tonnage handled, the normalized maintenance of the property to be abandoned is agreed upon by both companies. (By normalized maintenance we refer to an amount covering depreciation for a complete cycle of ties, rail, ballast, etc., together with ordinary maintenance required to keep the facilities in operation from day to day.)

(2) Deduct from the above normalized maintenance savings for property abandoned, the normalized maintenance required for the new connections.

(3) Also deduct from the above normalized maintenance savings the variation of maintenance with use which is the added cost of maintenance to the Owner Company for carrying the traffic of the User Company over its lines. (These costs represent the estimated actual out-of-pocket expense for handling the increased traffic and are not based on a pro-rata ton-mile share of normalized maintenance as in regular joint facility contracts.)

d. Transportation Savings

Under this category consideration is given to the additional or decreased transportation costs in train operation together with agency savings made by coordinating depots and other transportation costs which may be eliminated by reason of the coordination.

The net recurring savings determined from the sum of c and d above are then compared for each company, and the company with the excess savings would pay one-half the excess annually to the company with the lesser savings, this cost to be inflated from year to year on a trend basis to reflect as accurately as possible the estimated increased maintenance costs as they come about in the future.

The coordinated trackage can be handled by giving the User Company permanent joint use of the facilities, or joint ownership. If the coordinated trackage is to be jointly owned, each company transfers one-half of its facilities to be jointly used to the other company for a nominal consideration.

2. Description of Trackage Involved

This report covers two specific coordination projects which have been consummated under the principles outlined above. They involve parallel lines of the two companies

of about equal length, with one line of each company being retained for coordinated use. Fig. 1 shows the relative locations of the two railroads, mileage involved, and new connections required. A brief description follows:

a. Project No. 1. Railroad I line retained for joint use by Railroad II from B to B in Fig. 1, a distance of 24.3 miles, has 90-lb rail with creosoted ties on processed gravel ballast. The line of Railroad II has been abandoned from A to A, a distance of 24.59 miles.

Railroad I traffic includes one time freight, one local freight and one passenger train each way daily, and extra trains as required. Operation was by timetable and train order, no block signals being in use except for an automatic interlocking that was discontinued in the coordination.

Railroad II traffic includes one passenger train each way daily except Sunday, one tri-weekly local freight train, and extra trains as required. Operation was by timetable and train order, there having been no block signals.

b. Project No. 2. In the other case, Railroad II line has been retained for joint use by Railroad I from E to E in Fig. 1, a distance of 29.09 miles. This line consists of 85-lb rail on creosoted ties and gravel ballast. Railroad I line has been adandoned from C to C, a distance of 24.88 miles, and D to D, 2.21 miles.

The traffic over Railroad II includes two passenger and one time freight in each direction daily, one local freight train each way tri-weekly, and extra freight trains as required.

3. The Coordination

The coordinations were consummated on the basis that the superior line was retained in each instance, and brought about the abandonment of 51.68 miles of single main track; in addition, three local stations were made joint agencies.

4. Operation of Joint Trackage

a. Train Movement

Project No. 1. This segment of track is operated by timetable and train order, except for an 8.3-mile section at the east end where centralized traffic control is now in service, including electric lock at the point of connection. Westward trains of Railroad II stop short of the connection and call operator for clearance, which is accomplished by unlocking the switch; eastward trains receive clearance for operation from operator nearby the point of connection.

Project No. 2. This segment is operated entirely by timetable and train order. Westward trains of Railroad I receive operating clearance from Railroad II dispatcher through Railroad I operator at point of origin; eastward trains are cleared by operator at the junction point.

b. Maintenance

Each road maintains its own trackage in the coordinated area. Since the net annual maintenance savings for the two segments are about equal, there is no billing of one road against the other.

5. Cost and Savings

Exhibit A shows the cost of constructing the necessary connecting tracks, which cost was shared equally by the two roads. The total cost of construction was $163,185.

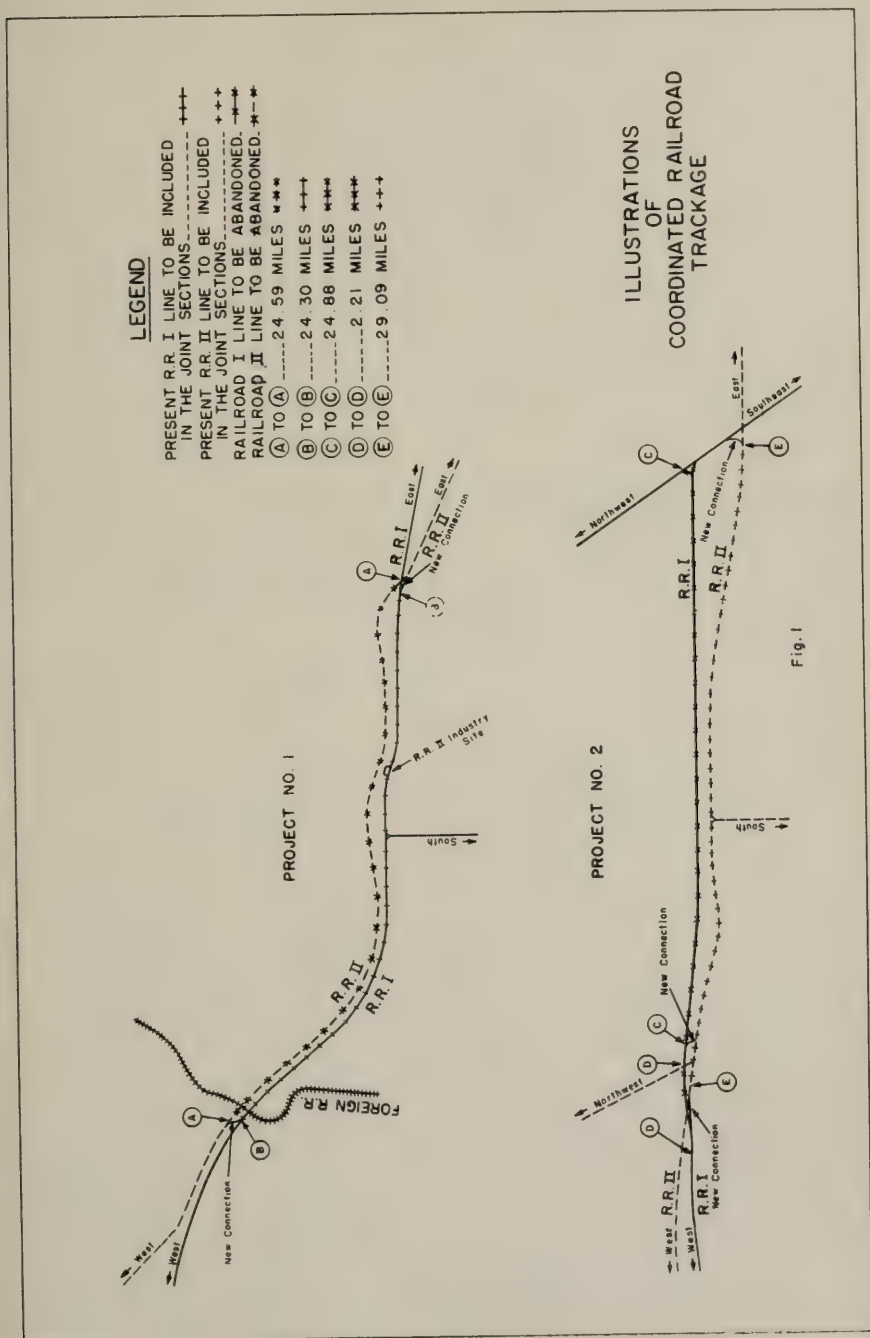
LEGEND
PRESENT R.R. I LINE TO BE INCLUDED IN THE JOINT SECTIONS
PRESENT R.R. II LINE TO BE INCLUDED IN THE JOINT SECTIONS
RAILROAD I LINE TO BE ABANDONED.
RAILROAD II LINE TO BE ABANDONED.
A TO A 24.59 MILES
B TO B 24.30 MILES
C TO C 24.88 MILES
D TO D 2.21 MILES
E TO E 29.09 MILES
PROJECT NO. 1
PROJECT NO. 2
ILLUSTRATIONS OF COORDINATED RAILROAD TRACKAGE
Fig. 1
FOREIGN R.R.
R.R. II Industry Site
New Connection
R.R. I
R.R. II
East
West
Northwest
Southeast
South

Exhibit A

Statement of Estimated Cost of New Connections

(Including Added Communications)

	Constructed by Railroad I	Constructed by Railroad II
Length of track	4,244 ft.	2,868 ft.
Total Cost	$106,475*	$ 57,600
Less Salvage	765	125
Net Cost	$105,710	$ 57,475

* Includes $49,325 for signals and communications.

TOTAL COST BOTH ROADS	$163,185

Each Road to pay 1/2, therefore:

Railroad I cost	$ 81,592
Railroad II cost	$ 81,593

Statement of Gross Salvage Value and Cost of Removal

(For trackage and other facilities abandoned)

	Railroad I	Railroad II
Bridges, Trestles & Culverts	$ 6,880	$ 3,852
Ties	26,856	37,850
Rail	132,614	116,793
Other Track Material	36,045	23,130
Station & Office Buildings	1,245	525
Communication Systems	6,650	--
Signals & Interlockers	200	2,125
Public Improvements	983	--
Right of Way	1,151	1,000
TOTAL SALVAGE	$212,624	$185,275
Cost of Removal	$ 69,489	$ 61,480
NET SALVAGE	$143,135	$123,795

Exhibit B

Summary of Annual Savings

	Savings	Railroad I	Railroad II
1.	Normalized Maintenance Eliminated	$ 51,345	$ 51,332
2.	Interest on Net Salvage (5%)	7,157	6,190
3.	Normalized Maintenance of RR crossings to be abandoned	--	153
4.	Station Savings	9,207	4,600
5.	Labor Taxes	1,130	1,271
	GROSS ANNUAL SAVINGS	$ 68,839	$ 63,546
	Deduct Additional Costs		
6.	Normalized Maintenance of New Connections	$ 6,214	$ 1,068
7.	Additional Maintenance required on Lines for joint use	5,282	2,758
	TOTAL ADDITIONAL COST	$ 11,496	$ 3,826
	NET ANNUAL SAVINGS	$ 57,343	$ 59,720

Exhibit A also contains a statement of the salvage and the cost of removal of the trackage that was abandoned. Each road removed its own trackage.

Exhibit B is a statement of the anticipated annual savings to be derived from the coordination. The total net annual saving is $117,063, of which $57,343 will accrue to Railroad I, and $59,720 to Railroad II.

In this case, the greatest saving is in the maintenance eliminated by abandoning the 51 miles of track.

CONCLUSION

This coordination was simple and straightforward by reason of the equal savings involved. Both companies feel that the anticipated savings are now being realized and that such joint use of facilities is of mutual benefit. The accomplishments are presented as information and indicate the economic possibilities that were made possible through joint efforts by the two companies.

In addition to the savings herein reported, track abandonment projects also carry an economic benefit through income tax savings on the write-off to operating expenses and the operating expense charge for effecting retirement; also the saving in annual property taxes from abandonment of property.

Report on Assignment 8

Innovations in Railway Operations

A. L. Sams (chairman, subcommittee), Herbert Ashton, J. W. Barriger, H. B. Christianson, Jr., P. J. Claffey, W. E. Quinn, L. K. Sillcox, C. W. Sooby, L. E. Ward.

Last year your committee presented a report listing several specific suggestions for innovations in railway operations and procedures. One of those suggestions dealt with the automation of train operation. In this progress report, which is submitted as information, the possibilities of automatic train operation in suburban passenger service are further explored.

Those familiar with railroad financial problems are aware of the difficulties facing a railroad management attempting to operate a commuter service at a profit. Under the near-monopoly conditions that existed in the past, a commuter railroad, which requires a large volume of business to sustain it, had an easier time producing a net profit. Now, however, despite increases in suburban population, the volume of commuting passengers is dwindling. Those communities now having a railroad commuter service recognize the need for the continuation of this service. However, efforts by the railroad managements to reduce annual operating deficits by fare increases or reductions in service are almost universally opposed by those communities, and usually with some degree of success. As a result, deficits from commuter operations are increasing from year to year, and are now reaching such serious proportions in some areas that subsidies from public bodies are under consideration.

If the commuter service is to be operated on a self-sustaining basis, some means of increasing revenue or decreasing operating costs must be devised. But increasing revenue by charging higher prices for the transportation evidently is not the answer, as the loss in traffic following a fare increase will attest. Vast expenditures of public funds for highway construction have benefitted automobile users to the extent that the railroad has largely lost the attraction of greater convenience over other forms of transportation. Therefore, the commuter railroad cannot regain an adequate volume of traffic to increase revenue appreciably. It is apparent that a profitable operation can be effected only by a reduction in expenses.

An examination of the operating expense statement of a commuter line will disclose that labor costs are the largest item. Generally, the cost of labor to operate the trains and handle tickets will exceed 30 percent of total expenses. This report presents an analysis of the application of automation to reduce these costs.

Automation is a little-known process when applied to railroad operations, as indeed it is in most other industries. The mechanization of some operations is more familiar, and is the first step in automation. The former provides a substitute for physical effort while the latter is designed to replace human mental processes. A machine, although it may perform the equivalent of the labor of many men, must have human supervision. For example, a power spike driver would continue to pound on the spike until it ran out of fuel or is stopped by the operator. On the other hand, if the spike-driving process were automated, the driver would drive the spike to the proper depth, then move to the next spike and repeat the process, until all spikes were driven, after which it would stop itself.

Because the automated operation is so involved, a necessary part of the planning is a careful analysis of each phase of the operation. All reasonably possible variables must be anticipated and provided for within suitable tolerance limits.

This report presents a study of the factors to be considered in the automation of a typical suburban passenger operation. No attempt is made to design or describe in detail the devices necessary to accomplish automation. Equipment is now available or can be

manufactured to perform the functions described herein. The purpose of this report is to determine what those functions must be.

The services that must be performed in providing suburban transportation are listed below. Each of these will be discussed more fully later in the report.

1. Sale of tickets or other means of identifying the transportation purchased.
2. Policing of ticket use.
3. Operation of trains.
4. Answering questions, supplying information, etc.
5. Miscellaneous local operations.

For the purpose of this study, it is assumed that the suburban facility consists of a typical layout several miles long and extending from one or more downtown stations to a suburban terminus. Intermediate stations are provided at convenient intervals and are designed to limit the movement of passengers through control points. Trains are operated in accordance with published schedules. The fare for transportation is related to the distance travelled, subject to a minimum and to discounts for quantity purchases. Peak periods occur inbound to the city in the morning and outbound at the close of the working days. Although the bulk of the travel is to and from the downtown stations, a significant amount exists between intermediate stations.

Discussion of the automation of the five services listed above follows:

1. Sale of Tickets

Mechanization of the sale of tickets does not present a difficult problem. Ticket vending machines are now on the market and are used satisfactorily at many locations. A device for making change for dollar bills and currency of larger denominations has been successfully tested and is now available. Both the ticket vending machine and the bill changer will require adequate precautions to prevent theft, and this must be taken into account in the design of the installation. The ticket-vending machine or machines at each station must be fitted to sell each type of ticket to each of the other stations on the line, except that multiple-ride and other tickets involving a large cash transaction may be handled by some other means. Instructions on the operation of the vending machine must be clearly stated and conveniently located.

2. Policing of Ticket Use

Under a manual operating system, ticket policing is performed before the passenger boards the train and again by the trainmen while enroute. When the operation is automated, however, the policing must be done by a mechanical process. This would be quite simple if a universal fare were in effect between all stations. However, the universal fare is not considered practicable if the suburban line is more than a few miles in length.

Several methods of policing ticket use in an automated system are possible. One method would require the establishing of two or more zones, with a universal fare within each zone and a surcharge for interzone movement. Under another method, passengers would be segregated by destination. A third possibility, and one that is most practical from all standpoints, is to collect the minimum fare before boarding the train and an additional fare upon leaving the train. The passenger would purchase a minimum fare token at the ticket-vending machine. This action would release the turnstile and permit one passage to the platform. Upon arrival at the destination station, the passenger would insert the token and the additional fare in the exit turnstile. A variation of this plan would permit the passenger to board the train without paying the minimum fare, and pay the entire fare at the destination. In either case, separate provision must be incor-

porated in the turnstiles to accommodate multiple-ride tokens and pass holders. If the multiple-ride tokens limit the number of rides within a given period, the mechanism must also punch out one ride each time the token is presented.

3. Operation of Trains

Automated, or crewless, train operation is entirely feasible from an engineering standpoint, as experiments have indicated. A suburban system is particularly adaptable to automation since the pattern of train movements is repetitious. The automatic equipment must be designed to start and stop the train, accelerate and decelerate as required by the track conditions, open and close the car doors, give warning signals at grade crossings, identify itself at interlockings, stop short of another train or obstruction, and report abnormal conditions so that necessary corrections can be made. In other words, it will be necessary to perform mechanically all of the functions of the locomotive engineer on a manned train.

4. Answering Questions, Supplying Information, Etc.

The trainmen on present manned trains also perform certain functions that are essential to the operations and must be continued by other means under an automated operation. The principle function, of course, is the policing of ticket use, which has been discussed earlier. Trainmen now announce the type and destination of the train, call the stations and inform the passengers about changing trains. All this type of information can be handled by recorded announcements coordinated with the train operation. A radio telephone installed in each car would provide a means for the passengers to obtain additional information from a central information desk.

5. Miscellaneous Local Operations

A suburban line may have contracts for carrying newspapers, mail or other parcels. Elimination of the train crew would make it necessary that another class of employee handle these parcels at originating and destination stations. If this is not possible, this business must be diverted to some other form of transportation.

Apart from the operating problems in connection with automation, there would be other objections to overcome. The equipment and operation must meet with the approval of regulatory bodies. Public acceptance of a radically new form of transportation would be a challenge for the public relations departments of the railroads. It may be helpful, in the interest of passenger acceptance, to adopt the innovations gradually over an extended period of time. The change may be opposed by railway employees, but they must be shown that the innovations will ultimately benefit them as well as the public.

In summary, complete automation of a commuter system is entirely feasible. The benefits to be gained by the railroads, the commuters and the communities served justify a full exploration of the economic factors involved.

Report of Committee 14—Yards and Terminals

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Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

A review has been started of the entire Chapter 14 of the Manual, with the purpose of bringing all of the material up to date before the Manual is reprinted in 1962. No changes are recommended this year, but an addition to the Manual to cover "Facilities for Loading and Unloading Rail–Truck Freight Equipment" is being recommended under Assignment 6.

2. Classification yards, collaborating with Committee 16.

Progress report on Present Trends in Design of Yards, submitted as information ..... page 261

3. Scales used in railway service, collaborating with Electrical Section, AAR.

Studies have been made on the relative accuracy and possible advantages of weighing cars by the so-called "two-draft" method. Further studies are to

be made, however, and a report on this method of weighing will be submitted in 1961.

4. Gradients for flat switching yards.
   Final report, presented as information ..... page 262

5. Influence of roller bearing cars on design of hump and flat yards.
   Final report, presented as information ..... page 263

6. Facilities for loading and unloading rail-truck freight equipment.
   Report submitted with the recommendation that it be adopted and published in the Manual ..... page 263

7. Water front terminals.
   Progress report on Coal Piers, presented as information ..... page 264

8. Present trends in yard maintenance.
   Progress report, submitted as information ..... page 267

THE COMMITTEE ON YARDS AND TERMINALS,
A. S. KREFTING, *Chairman.*

AREA Bulletin 553, November 1959.

Report on Assignment 2

Classification Yards

R. O. Balsters (chairman, subcommittee), R. F. Beck, H. R. Beckmann, A. E. Biermann, H. P. Clapp, B. E. Crumpler, A. V. Dasburg, Oscar Fischer, H. C. Forman, W. H. Giles, J. E. Griffith, A. S. Krefting, B. Laubenfels, Glen Lichtenwalner, E. T. Lucey, S. N. MacIsaac, H. J. McNally, J. C. Miller, R. F. Moris, C. J. Morris, A. G. Neighbour, L. F. Pohl, W. H. Pollard, R. E. Robinson, L. R. Shellenbarger, R. A. Skooglun, F. R. Smith, Jack Sutton, J. J. Tibbits.

Present Trends in Design of Yards

Your committee presents as information the following report on Present Trends in Design of Yards.

Since the general arrangement of the receiving, classification and departure yards was studied and the resulting report published in the Proceedings, Vol. 55, 1954, pages 429–445, more yards have been constructed with the departure yard alongside the classification yard.

The trend toward complete automation is evident in many of the hump yards now in operation and under construction. One tower, centrally located with relation to the retarder area, provides unified control of the classification of cars by one operator.

Automation requires test sections at strategic locations between the crest and the group retarder for the measurement of rolling resistance. The length of track over the track scale, if one is installed at the hump, is used as part of the test section.

Power-operated switches are being used to advantage in routing trains in and through the receiving and departure yards. Track-designation and track-occupancy indicators are being used in the receiving yard and shove-indicators in the departure yard.

By-pass tracks are being provided to facilitate the escape of the hump engine.

Dragging-equipment and broken-flange detectors are being placed in the lead to the hump in advance of inspection facilities. Flange lubricators are being placed at strategic locations.

The use of lap switches and greater frog angles minimizes the distance from the first switch to the farthest clearance point. The use of bent stock rails on both sides of equilateral turnouts facilitates the "packaging" of turnouts.

Welded rail is being used in portions of the yard where short track circuits are unnecessary.

Yards are being built or contemplated with a trend toward flatter or level grades in the body tracks.

Talk-back speakers at strategic locations throughout the yard are conducive to a well-coordinated operation. Television at the entrance to the receiving yard and voice recorders in the yard office are used to expedite the preparation of hump lists.

The trend to increase the length of cars may require using a length of more than 45 ft per car in figuring the car capacity of yard tracks. This subject has been previously studied, and the report on it appears in the Proceedings, Vol. 50, 1949, pages 213–215.

Report on Assignment 4

Gradients For Flat Switching Yards

B. E. Crumpler (chairman, subcommittee), M. H. Aldrich, F. E. Austerman, R. F. Beck, H. R. Beckmann, W. O. Boessneck, H. P. Clapp, A. V. Dasburg, H. C. Forman, Wm. J. Hedley, F. A. Hess, A. S. Krefting, B. Laubenfels, G. Lichtenwalner, E. T. Lucey, G. W. Mahn, Jr., A. G. Neighbour, R. H. Peak, Jr., L. F. Pohl, L. J. Riekenberg, L. W. Robinson, R. E. Robinson, W. C. Sadler, L. R. Shellenbarger, R. A. Skooglun, Jack Sutton, J. J. Tibbits, P. P. Wagner, W. E. Webster, Jr.

This report, on a new assignment, is presented as information with the recommendation that the subject be discontinued.

Flat switching yards are defined in the AREA Glossary as "yards in which movement of cars is accomplished by a locomotive without material assistance from gravity." It is further apparent that flat switching is done without the use of car retarders or car riders and, generally, without the use of power-operated switches.

The present-day trend for economical railway operation is to reduce between-terminal switching to a minimum, performing the majority of car classification work in large modern, retarder-operated classification yards. There are many locations, however, where flat switching yards may be found more economical and efficient for the business to be handled. Considering the variety of requirements, the economics of each specific location must be thoroughly weighed before selecting the type of yard.

Certain benefits can be obtained in flat yards by installing gravity leads, or so-called saucer gradients, one being that a greater number of cars can be handled than in an absolutely flat yard. Assisting gradients for this type of yard are dependent on many factors, such as climate, rollability of cars, type of ladders, curvature of turnouts, alinement, prevailing winds, and the standards to which the tracks are maintained.

These assisting gradients are desirable and should be sufficient to assure that most cars will roll beyond the clearance points without excessive effort on the part of the switch engine. The gradients beyond the clearance points should not produce undue acceleration.*

Except for variable conditions and local limitations, satisfactory operation can be obtained by providing a 0.3-percent descending grade to the leaving ends of ladder-track turnouts and a 0.1-percent descending grade beyond the ladder-track turnouts, but compensating for curvature betwen the ladders and the straight portion of body tracks at AREA recommended rates.*

Adverse grades at the far end of single-ended yards are advisable.* It is recommended that minimum grades be installed since it is more economical to raise track to obtain steeper grades than to lower track to obtain flatter grades.

A questionnaire was submitted to committee members, and the accompanying tabulation of replies presents characteristics of 19 existing flat yards, together with certain recommendations for new yards.

* See AREA Manual, page 14–3–11.

Railroad	
AT & SF	Bar
CB & Q	N.Ka (Mu
G.T.W.	Batt Mich
I.C.	New (Ma
"	Memp John
L & N	Loui (St
"	Chat
N.Y.C.	Crot (
"	Yonk
N.P.	Minne ("A
"	Dulut (Ric
"	Stapl
"	Laure
"	Misso
"	Aubur
"	Yardl
T & P	Big S
Union	N.Bes
Wabash	Oakwo (W.En

GRADIENTS FOR FLAT SWITCHING YARDS

TABULATION OF REPLIES TO QUESTIONNAIRE

Railroad	Location of Yard	No. of Tracks	Type of Ladders	Average Lgth. From Uncoupling Pt. to Foot of Ladders Feet	Average Clear Lgth. of Tracks Feet	GRADES AND DISTANCES: Apex to Foot of Ladder % Grade	Apex to Foot of Ladder Dist. Feet	Foot of Ladder to Clear. Point % Grade	Foot of Ladder to Clear. Point Dist. Feet	Beyond Clear. Point % Grade	Beyond Clear. Point Dist. Feet	Adverse Grades % Grade	Adverse Grades Dist. Feet	Present Operation Satisfactory?	IF NOT, % GRADE RECOMMENDED: Apex to Foot of Ladder	Foot of Ladder to Clear. Pt.	Beyond Clear. Pt.	Adverse Grades	COMPENSATED: For Curvature	For Turnouts	No. Cars Switched Per 8-Hr Shift	Avg. No. of Cars Per Cut	AVERAGE SPEED OF CARS - mph: When Uncoupled	At Foot of Ladder	In Body Tracks	Avg. Dist. Cars Roll Beyond Clear. Pt. Feet	Amount Trimming Necessary	Amount Impact Damage	Remarks
AT & SF	Barstow, Calif.	18	Lg.Dbl.		4800	0.40		0.40		0.18 to 0.12				Yes	- -	- -	- -	- -	No	No	1000	3 - 4					Average	Average	Yard switched from both ends - Similar grades.
CB & Q	N.Kansas Cy.,Mo. (Murray Yard)	20	Lg.Dbl.	1200	1800					Very Flat		0.25	300	No	0.35	0.35	0.00	0.50	No	No	600	3	7	6	4		"	"	
G.T.W.	Battle Creek, Michigan	2c	Lg.Sing. Both Ends	No Fixed Uncoupl.Pt.	2900	0.24 to 0.14	1100	0.20	120	0.20	1400 to 400			Yes	- -	- -	- -	- -	No	No	500-600	3	5	5	4	1700 to 700	Negligible	Negligible	Yard switched from both ends - Similar grades.
I.C.	New Orleans, La. (Mays Yard)	22	Dbl.Ladd. Each End	600 to 1500	4300	0.30		0.30		0.30	500			No	0.30	0.30	0.10	- -	No	No	400	1 or 2				500	Average	Average	Yard switched from both ends - Similar grades.
"	Memphis, Tenn. Johnston Yard	53	Lg.Dbl.	1500	4200	0.10 to 0.18	800 to 1700	0.10 to 0.18		0.00									No	No	2000	3	6	5	3 - 4	1000	Considerable	Considerable	
L & N	Louisville, Ky. (Strawberry)	25	Lg.Sing.	N.End 1560 S.End 840	3460	0.34 0.20	1150 675	0.43 0.20	215 215	0.42 0.20	2430 800	0.44 0.20	3800 2900	No	0.30	0.30	0.10	0.30	No	No	500	1 to 6	2	6	4	900	Negligible	Negligible	Riders used.
"	Chattanooga, Tenn.	19	Lg.Sing. Lg.Dbl.	1000	2400	0.30	NE 1800 SE 800	0.30	130	0.10	1250	0.10 0.30	850 1000	Yes	- -	- -	- -	- -	No	No	300	1 to 10	4	4	4	1200	"	"	
N.Y.C.	Croton (West Yard)	15	Lg.Sing.	1450	2385							None		No	0.30	0.50 to 0.30	0.15	0.11	No	No	300	1 to 20	6	4	2	400	Considerable	Average	
"	Yonkers, N.Y.	8	Group	800	1150	0.54	800	0.54	150	0.00	300	0.46 1.00	400 300	No	0.30	0.50 to 0.30	0.15	0.11	No	No	75	13	1½	4	6	600	Negligible	Considerable	Riders used for certain commodities.
N.P.	Minneapolis, Minn. ("A" Northtown)	18	Lg.Sing.	760	3900					0.08		None		Yes	- -	- -	- -	- -	No	No	71	1 to 4	6½	5	4		Average	Average	
"	Duluth, Minn. (Rices Point)	54	Group	700	2800					0.50 to 0.00		None		Yes	- -	- -	- -	- -	No	No	63	1 to 4	6½	5	4		"	"	
"	Staples, Minn.	21	Sh.Dbl.	900	6000					0.20		None		Yes	- -	- -	- -	- -	No	No	374	1 to 4	6½	5	4		"	Negligible	
"	Laurel, Mont.	40	Lg.Trip.	670	5000					0.35		None		Yes	- -	- -	- -	- -	No	No	170	1 to 4	6½	5	4		"	Average	
"	Missoula, Mont.	13	Lg.Sing.	500	6500					0.33		None		Yes	- -	- -	- -	- -	No	No	144	1 to 4	6½	5	4		"	Negligible	
"	Auburn, Wash	20	Lg.Dbl.	700	3600					0.25		None		Yes	- -	- -	- -	- -	No	No	140	1 to 4	6½	5	4		"	Average	
"	Yardley, Wash.	14	Lg.Sing.	300	5000	0.35	1800	0.35	100	0.35	1000	None		Yes	- -	- -	- -	- -	No	No	500	1 to 4	3	3	3	1000	"	"	
T & P	Big Spring, Tex.	6	Lg.Sing.	350	3300		VERY FLAT GRADES							Yes	- -	- -	- -	- -	No	No		3				600	Negligible	Negligible	Yard switched from both ends - Similar grades.
Union	N.Bessemer, Pa.		Lg.Sing.		3000			0.60		0.60	3000	None		No					No	No	300	7	2	3	6	300	Average	"	
Wabash	Oakwood, Mich. (W.End Class.Yd.)	15	Lg.Sing.	2100	3200			0.18		0.07		None		Yes	- -	- -	- -	- -	No	Yes	200	1 to 4	3	4	4	900	Neglibible	"	

Report on Assignment 5

Influence of Roller-Bearing Cars on Design of Hump and Flat Yards

W. H. Goold (chairman, subcommittee), M. H. Aldrich, R. O. Balsters, W. O. Boessneck, H. P. Clapp, A. V. Dasburg, W. H. Giles, J. E. Griffith, A. S. Krefting, B. Laubenfels, A. G. Neighbour, L. J. Riekenberg, L. R Shellenbarger, R. A. Skooglun.

Your committee has investigated the subject and to date has found nothing significant other than what is recorded in the Proceedings, Vol. 58, pages 476 and 1115. It is recommended, therefore, that the subject be discontinued.

Tests have been to determine the rolling resistance of roller-bearing cars, and the results have indicated no appreciable difference between them and cars with solid or friction bearings, except for lower starting friction and greater uniformity in rolling resistance. If grades have been designed for the easy-running friction-bearing cars, then the roller-bearing cars can be handled without difficulty.

Report on Assignment 6

Facilities for Loading and Unloading Rail-Truck Freight Equipment

H. J. McNally (chairman, subcommittee), M. H. Aldrich, H. R. Beckmann, F. G. Benner, A. E. Biermann, W. O. Boessneck, G. H. Chabot, Oscar Fischer, C. A. Hagan, Wm. J. Hedley, J. E. Hoving, A. S. Krefting, B. Laubenfels, G. Lichtenwalner, J. L. Loida, E. T. Lucey, S. N. Mac Isaac, T. F. Maloney, Jr., J. C. Miller, R. F. Morris, B. G. Packard, L. J. Riekenberg, L. W. Robinson, R. E. Robinson, J. J. Tibbits, P. P. Wagner.

The committee recommends that the following new Sec. J be added to Manual, Chapter 14, Part 3, Freight Terminals, titled "Rail-Truck Loading and Unloading Facilities". It also recommends that the subject be continued for further study.

J. RAIL-TRUCK LOADING AND UNLOADING FACILITIES

Four types of facilities are used:

1. End loading.
2. Side loading.
3. Overhead loading.
4. Combination rail–highway vehicles.

1. End loading of railroad cars is accomplished by backing the tractor–trailer–truck combination on a flat car or string of cars from a platform or ramp constructed to car-floor height.

2. Side loading can be accomplished by the use of a fork lift truck, a platform at car-floor height, or by the use of special equipment which permits separation of the trailer body from its wheels and transfer of the body to a flat car.

3. Overhead loading can be accomplished by the use of a traveling, overhead rail-mounted or tire-mounted crane. Either the entire trailer or the trailer body without wheels can be handled from the roadway adjacent to the track.

4. The combination rail–highway vehicle employs special truck equipment with tire-mounted and flanged wheels which can be raised or lowered as required. The handling area is paved to the top of rail.

The selection of the location and area required for the facility depends upon the potential volume of traffic, its origin and destination within the service area, the convenience of highway access and the necessity for economical and expeditious movement of railroad cars. As many as eleven 85-ft cars in a string can be used in end-loading operations efficiently. A trailer parking area of at least the capacity of the loading tracks should be planned. Many installations have a parking area with a capacity two or three times the track capacities.

The paving of parking area, driveways and ramps should be considered. The ramps may be of wood, concrete or earth-filled-crib construction. Platform walkways adjacent to tracks should be considered to provide easy movement of men from one car to another.

Lighting in the track area should be furnished to facilitate tie-down operations. Parking areas should be lighted if there is considerable night operation.

The larger operations will require an office and locker room at the site. A truck scale may be required. Fencing may be worthwhile to assist policing. Drainage of track, driveway and parking area must be considered. Communication facilities within and beyond the operation area should be provided for efficiency. Facilities for repair of truck and tie-down equipment may be required.

Report on Assignment 7

Water Front Terminals

W. H. Pollard (chairman, subcommittee), M. H. Aldrich, F. E. Austerman, F. C. Benner, A. E. Biermann, W. P. Buchanan, G. H. Chabot, B. E. Crumpler, C. A. Hagen, J. E. Hoving, A. S. Krefting, J. L. Loida, E. T. Lucey, G. W. Mahn, Jr., H. J. McNally, B. G. Packard, H. T. Roebuck, W. C. Sadler, Jack Sutton, J. W. Tucker, W. E. Webster, Jr., C. F. Worden.

Coal Piers

Your committee presents as information the following report covering coal piers.

Railroads serving the bituminous coal fields in the United States transport a large percentage of the coal mined to their waterfront terminals where it is transferred from cars to vessels by coal-handling facilities located on piers or marginal wharves, commonly referred to as coal piers.

This report describes briefly three principal types of coal piers employed for this use—the high-level pier, the low-level pier and the belt-conveyor pier.

High-Level Pier

The high-level piers were constructed in the early part of the 20th century. From inshore to outshore, this type of pier consists of the following primary components: a car-thawing plant, a barney haul, a car dumper, a track scale (in some instances located on the lead track to the barney pit), an elevator for service cars, a pier perpendicular to the shore line approximately 1200 ft long, 90 ft high and 70 ft wide, with service car track on each side at the top extending from the elevator to the outshore end, and a single return track from the outshore end of the pier back to the dumper at the inshore end. This type of pier will accommodate four average-size vessels, two on each side.

The pier may be served from a loaded-car yard with a gravity-grade or a flat-grade yard requiring some type of pusher power to place the cars on the barney pit. The operation of this facility as originally constructed may be described, from inshore to outshore, as follows: cars move from the loaded-car yard through the thawing plant

to the barney pit, from which they are pushed up an incline onto the car dumper by the barney, which engages the rear coupler of the car. The barney operates on a narrow-gage track having a common center line to the standard-gage track, and from a pit which allows the cars to pass over it. The barney is pulled up the incline, while shoving the car in front of it, by a head rope from an electrically powered drum in the barney machinery building, which is usually located directly under the incline and near the approach to the car dumper. Limit switches are provided to stop the barney after it shoves the car far enough on the dumper to push the preceding car off and allow the car being delivered to be properly spotted on the dumper by the use of retarders.

The empty car rolls by gravity from the dumper through a spring switch to a kick-back that reverses the movement of the car back through the spring switch to the return or empty-car yard. The coal from the loaded car is dumped into an electrically driven transfer or service car large enough to take the load of two railroad cars. The transfer car, after being loaded, moves over the track scale where the weight is recorded and onto tne elevator where it is raised to the top of the main pier structure.

At the top and along each side of the pier structure, storage bins of approximately one car capacity are provided on 30-ft centers under the service-car track. The service cars, which have dump bottoms, empty their load into the storage bins. A vertical slide box with telescopic front plates and an adjustable angle chute is provided under each storage bin, which is equipped with a gate. The coal is delivered through these slide boxes and chutes to the vessel being loaded.

These earlier piers provided no means of controlling the flow of prepared coal, and to overcome this condition, most of them have been modernized by removing the slide boxes and chutes and installing traveling sidewall loaders with pan, hopper and telescopic chute equipped with rotate and trimmer to deliver coal from the storage bins to the holds of the vessel being loaded.

Low-Level Pier

The low-level piers in some cases are built perpendicular to the shore line and in others parallel to it. This type of pier is usually about 1000 ft long and 70 ft wide and has a stationary single-car dumper located approximately midway of its length.

The principal components of this type of pier from inshore to outshore consist of a car-thawing plant, a track scale, a barney haul and a dumper. It may be served by a loaded-car yard with gravity grade or flat-grade yard requiring car pushers to place the cars on the barney pit. In some instances the barney haul might be omitted and the cars placed on the dumper cradle by a side-arm pusher.

The cradle, including a loaded car, is hoisted to pan elevation and rotated to dump position. The pan's width at the receiving end is equal to the length of the cradle and is tapered to approximately 6 ft at the outboard end to permit delivery of coal to a square hopper of nearly the same size. A telescopic chute with rotate and a variable-speed belt-conveyor-type of trimmer with a gate attached to its lower end is suspended from the hopper at the outboard end of the pan. The hopper is made up of two sections and is pinned at 90 deg to permit swinging the telescopic chute and trimmer approximately 20 deg from the vertical position in any direction by use of four chute blocks extending from the pan structure to the rotate housing at the lower end of the chute. By swinging the chute, and rotating trimmer, including the racking in and out of the belt conveyor in the trimmer, the holds of the vessel can be completely filled without hand trimming. The power-operated gate on the trimmer permits keeping the

chute and hopper full of coal, thereby controlling its flow. Other types of trimmers with fixed conveyors are adaptable to this facility. Where only open-type vessels are loaded, a cowl trimmer is usually employed in lieu of the belt trimmer.

Piers of this type require hauling the vessel fore and aft to place its various holds adjacent to the dumper. This is accomplished by the use of two power-operated constant-tension winches with fair leads, one located on pier deck near each end of the pier. A steel cable is run from the winch through the fair lead to the bow and stern of the vessel. Two power-operated capstans are also used for breast lines to hold the vessel to the pier. In some cases the vessel is hauled by its own winches.

The movement of cars on these piers is similar to that on the high-level pier in that the empty car is kicked off the dumper by the following loaded car and moves over a kickback to the return yard.

Belt-Conveyor Type Piers

The belt-conveyor type of pier is employed to a large extent in present-day installations of coal-handling facilities. The capacity per belt of this type of pier ranges from 1500 to 6000 tons per hr.

The facility may be constructed perpendicular to the shore line or parallel thereto, as conditions require. There may be a stationary loading point for vessels, or traveling towers might be employed. The traveling-tower method is more often selected as it does not necessitate hauling the vessel. A pier constructed perpendicular to the shore line is normally about 1100 ft long and 80 ft wide and will permit the berthing of two large vessels on each side. If constructed parallel to the shore line, provision is normally made for berthing one vessel at a time.

Loaded cars may be fed to the pier from a loaded-car yard with gravity grade or a flat-grade yard requiring car pushers.

The principal components of this type of pier from inshore to outshore normally consist of a track scale (if pier-site weighing is required), a car-thawing plant, a barney pit, incline and barney haul, a dumper with an empty-car return track, reciprocating or belt feeders under dumper, a collector belt, a main pier belt, a bridge belt to the loading tower, loading tower, boom belt, telescopic chute, rotate and trimmer. All of these components are electrically powered where possible and synchronized for automatic push-button operation.

There may be one or as many as four of these systems combined into one pier, and the loading tower, if of the traveling type, moves the entire length of the pier. Rotary dumpers are more commonly used, and a pier provided with four loading towers and belts also has four dumpers, two on each side, that can dump one or two cars at a time. The barney haul system is also designed to handle either one or two cars to the dumpers on each side of the pier. In most cases the empty cars kicked off the dumpers roll by gravity through a spring switch to a kickback where their movement is reversed to the empty-car yard tracks. Some piers of this type have a total capacity of 6000 tons per hr.

The Chesapeake & Ohio Railway placed in operation in 1958 at Presque Isle, Toledo, Ohio, what is believed to be the largest single-vessel coal-loading pier in the world. It is a belt-conveyor type of facility, and the capacity of the single movable tower is 6000 tons per hr.

The loading facility is constructed parallel to the shore line on "made" land which is retained by a relieving-type platform bulkhead. Its components consist of a level-grade loaded-car yard with eight tracks and six diesel–electric car pushers, a barney haul, two rotary car dumpers connected in tandem, a descending semi-circular exit track

leading to an empty-car yard equipped with electro-pneumatic car retarders, six variable-speed belt feeders from dumper hoppers, an 8 ft wide collector belt, an 8 ft wide incline belt, an 8 ft wide main pier belt, an 8 ft wide fixed tower conveyor, and an 8 ft wide shuttle conveyor. The loading tower is equipped with a boom that can be raised to a near-vertical position to clear vessels being docked. A telescopic chute is suspended from the outboard end of the shuttle conveyor and is equipped with a cowl trimmer supported on a double-acting ball-rack rotate. A belt-conveyor trimming machine is also adaptable to the rotate.

The barney haul maximum forward speed under load is 900 ft per min and the reverse travel is 1400 ft per min. It delivers two 70-ton cars to the dumpers every 55 sec and requires 2000 hp. The rotary car dumpers have a cycle of 40 sec over and back. The six feeder conveyors are variable speed and are regulated by a conveyor scale located under the incline conveyor belt. With this arrangement the conveyor system can be fed at any rate from 1000 to 6000 tons per hr. The total power required to drive the conveyor system is 1350 hp.

Report on Assignment 8

Present Trends in Yard Maintenance

C. J. Morris (chairman, subcommittee), F. E. Austerman, R. O. Balsters, R. F. Beck, F. G. Benner, A. E. Biermann, H. P. Clapp, A. V. Dasburg, H. C. Forman, W. H. Goold, J. E. Griffith, C. A. Hagen, F. A. Hess, A. S. Krefting, J. L. Loida, E. T. Lucey, T. F. Maloney, A. G. Neighbour, C. F. Parvin, R. H. Peak, W. H. Pollard, L. J. Riekenberg, R. E. Robinson, F. R. Smith, J. Sutton, P. P. Wagner, W. E. Webster.

Your committees submits as information the following report on current trends in the use of material and labor in yard maintenance, with the recommendation that the subject be continued.

Traditionally, railroads have maintained tracks on their main lines to a higher standard than in yards. The application of improved materials and the mechanization of work methods on line territory has resulted in better and more economic maintenance. The satisfactory progress attained in this field has recently permitted more attention to be directed to yard requirements, resulting in a trend to maintain yards to an increasingly high standard, which will:

a. Expedite the handling of cars in and out of yards.
b. Permit faster classification of cars.
c. Reduce damage to lading during classification operations.
d. Maintain performance of speed-control devices.
e. Minimize interference to yard operations.
f. Reduce long-range maintenance costs.
g. Improve safety and working conditions for yard personnel.

Improved maintenance of yards is being obtained by:

a. Use of better track materials.
b. Increased mechanization of maintenance operations.
c. More programming of maintenance work.
d. Better deployment of yard maintenance forces.
e. Fuller cooperation from operating personnel.

Maintenance of tracks to a higher standard in receiving and departure yards and the selection of longer turnouts have permitted trains to be yarded and dispatched at higher speeds than previously. Adoption of more rigid standards for alinement, surface, cross-level, gage, joint tightness and rail-end batter has resulted in greater consistency in the rolling speed of cars. This has permitted switching crews or mechanical car controllers to classify cars faster and to judge more accurately the proper speed of release, thereby minimizing damage to lading from impact. A high standard of maintenance is essential to ensure satisfactory performance of speed-control devices where these are used in hump classification yards.

By speeding up work methods and by performing work more thoroughly, both the frequency and the time required to perform maintenance operations have been reduced, hence interference to yard operations has been minimized and long-term maintenance costs have been lowered. Good maintenance is conducive to safety, and both will improve working conditions for yard forces.

To attain the economy which results from better car handling through yards and from more efficient yard maintenance, the trend is to use better materials, mechanize maintenance operations more fully, program work and deploy maintenance men more prudently. It is intended to examine carefully each of these aspects of this trend and to set down the findings in a further report.

Report of Committee 9—Highways

J. M. Trissal, *Chairman,*
R. W. Mauer,
Vice Chairman,
R. E. Skinner, *Secretary,*

W. S. Autrey
F. N. Barker
Bernard Blum (E)
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H. B. Clarkson
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E. R. Englert
J. T. Fitzpatrick
T. L. Gibson
P. J. Harnish
C. I. Hartsell
Wm. J. Hedley
J. T. Hoelzer
J. A. Holmes
W. H. Huffman
E. Q. Johnson
Maro Johnson (E)
J. A. Jorlett
J. E. K. Krylow
J. R. Latimer
R. L. Lemon
J. F. Mark
H. L. Michael
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F. T. Miller
H. G. Morgan (E)
R. E. Nottingham
G. P. Palmer (E)
R. J. Pierce
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P. H. Slack
R. F. Spars
C. W. Traister
T. M. Vanderstempel
V. R. Walling (E)
Raymond Westcott
Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   The committee is actively progressing review of its Chapter in the Manual, looking to completing this review by 1962.

2. Merits and economics of prefabricated types of highway–railway grade crossings.

   Progress report, submitted as information ..... page 270

3. Merits of various types of highway–railway grade crossing protection, collaborating with Signal Section AAR.

   Progress report, submitted as information ..... page 271

4. Relative effective visibility of highway–railway crossbuck signs of various sizes, colors and materials.

   Brief report, presented as information ..... page 272

5. Recommended method of developing annual maintenance cost of the various types of highway–railway grade crossing protection, collaborating with Signal Section, AAR.

Data are being assembled concerning present experience of various railroads in determining maintenance costs of individual grade crossing protection facilities; also, the status in the different states regarding any division of this maintenance expense. Analysis of these data will provide the basis for committee recommendations.

8. Recommended protection at highway–railway grade crossings where one-way traffic on the highway crosses one or more tracks on the railway, collaborating with Signal Section, AAR.

Final report, with plans and requisites submitted for adoption and publication in the Manual ..... page 273

THE COMMITTEE ON HIGHWAYS,
J. M. TRISSAL, *Chairman.*

AREA Bulletin 553, November 1959.

Report on Assignment 2

Merits and Economics of Prefabricated Types of Highway–Railway Grade Crossings

R. E. Nottingham (chairman, subcommittee), F. N. Barker, C. A. Christensen, H. B. Clarkson, M. H. Corbyn, H. E. Dearing, R. Dejaiffe, J. T. Hoelzer, W. H. Huffman, J. R. Latimer, E. S. Miller, R. E. Skinner, P. H. Slack, R. Westcott.

Your committee presents as information the accompanying table showing the estimated costs to install and maintain various types of highway–railway grade crossings based on data secured from several railroads.

COMPARISON OF ESTIMATED COSTS TO INSTALL AND MAINTAIN VARIOUS TYPES OF SINGLE-TRACK HIGHWAY–RAILWAY GRADE CROSSINGS 30 FT LONG

Type of Material	*Est. Avg. Life, Years*	*Original Cost*	*Original Cost Per Track Ft.*	*Renewal Cost Per Year*	*Maint. Cost Per Year*	*Annual Cost*	*Annual Cost Per Track Ft.*
Cold-mix bituminous with creo. gum guard timbers	8	$ 360.00	$ 12.00	$ 45.00	$ 60.00	$105.00	$ 3.50
Creo. red oak pre-fab panels, shop made	12	645.00	21.50	53.75	51.00	104.75	3.49
Creo. gum pre-fab panels, factory made	16	759.60	25.32	47.47	51.00	98.47	3.28
Creo. gum panels as above with rubber pads under timber and rails	20	939.60	31.32	46.98	27.00	73.98	2.47
Creo. red oak as above with rubber pads	16	825.00	27.50	51.56	27.00	78.56	2.62
Heavy metal galvanized open-grating panels	20	1,650.00	55.00	82.50	45.36	127.80	4.26
Pre-fab concrete slabs	20	1,412.40	47.08	70.62	60.00	130.62	4.35
Pre-fab rubber panels	25	2,430.00	81.00	97.20	30.00	127.20	4.24
Pre-fab rubber panels	20	2,430.00	81.00	121.50	30.00	151.50	5.05

The figures reported on maintenance costs are based on actual repairs to the surfacing material and also the frequency of resurfacing required on account of the effect of the type of material on the roadbed conditions. The figures received vary considerably, probably because of different physical conditions, such as drainage of roadbed, type of ballast, location of crossing with reference to labor headquarters, and effect of frost heaving or other climatic conditions, as well as volume of railway and highway traffic.

In most cases accurate maintenance costs are not available and must be estimated.

Some of these types have been under test for only five years, which is considered inadequate for a firm conclusion. One metal-type material for which a 25-year life was claimed started failing after 8 years. Another similar but heavier metal-type material is giving good service but under light highway traffic and more-than-average favorable conditions. Maintenance figures on only one of this type of crossing is presented.

Timber-panel and concrete-slab prefabricated materials have been in use for many years. Rubber strips and rubber pads have been used in connection with timber-panel installations for about three years and have shown some merit. Railroads have generally found concrete-slab material unsuited to present-day highway traffic.

For comparison the committee has included the estimated costs of a cold-mix bituminous-paved crossing with one creosoted-timber plank on each side of the rails. They are based on a track area 9 ft wide and include all costs for paving above the tops of the ties. It is assumed that the drainage conditions have been made good, new creosoted ties installed on proper roadbed, and the track resurfaced.

These estimates are not considered as final and may be changed by more accurate figures on maintenance costs and expected service life of the materials used.

Your committee recommends that the subject be continued.

Report on Assignment 3

Merit of Various Types of Highway–Railway Grade Crossing Protection

Collaborating with Signal Section, AAR

J. A. Jorlett (chairman, subcommittee), W. S. Autrey, A. C. Cayou, M. H. Corbyn, R. Dejaiffe, E. R. Englert, Wm. J. Hedley, J. A. Holmes, E. Q. Johnson, J. E. K. Krylow, J. R. Latimer, H. L. Michael, R. E. Nottingham, G. P. Palmer, C. W. Traister, P. H. Slack, R. F. Spars.

In 1957 the Armour Research Foundation, under an arrangement with the Association of American Railroads, processed the data of the characteristics of 2291 Chicago, Rock Island & Pacific highway–railway grade crossings in Iowa and the 1395 accidents that had occurred over the 16-year period, January 1, 1941, to December 31, 1956. The data, tabulated on IBM cards, were processed on the Foundation's 650 digital computer. In the 1958 Proceedings, Vol. 59, page 1162, is a detailed report of this project presented by G. M. Magee, director of engineering research, AAR. He cited the prediction equation that was evolved and made suggestions for further investigation. The prediction equation produced contradictory results, which was attributed either to inconsistent and insufficient data or unknown factors that interacted with known crossing characteristics.

Your committee felt that additional information should be obtained on more crossings with improved and upgraded protection, and contacted the State of Ohio in regard to a survey that had been made of the physical characteristics of railroad crossings in Ohio. This state has 10,852 highway–railway grade crossings, ranking fifth in the nation. Of these, 2,725 have some type of protection other than fixed crossbuck signs. Ohio ranks fourth in the number of auto-train accidents and also rates quite high in the number of fatalities, although the number has been declining steadily over the past two decades.

The State of Ohio has recognized the importance of determining the potential hazard of a crossing and for many years has used the Bureau of Public Roads' formula, the study of Wm. J. Hedley, chief engineer of the Wabash Railroad, and also some of its own ratings. However, it is desirous of determining a formula suitable to Ohio's

crossings and has formulated the physical characteristics of each of its crossings on duplicate IBM cards and furnished them to the AAR for this study at no cost. Early in 1959 it was agreed by the State of Ohio, the director of engineering research for the AAR, and your committee that the highway–railway grade crossing accident records over a 10-year period of the 14 largest railroads operating in Ohio would be more representative of crossing conditions for the continued grade crossing hazard rating survey than those on the Rock Island in Iowa. These 14 railroads in Ohio have furnished their accident records for the 10-year period from 1948 to 1958 at nominal cost to cover the preparation of their summary reports. The Armour Research Foundation is classifying the data, preparing summary tables for the investigation of correlation between accidents and grade crossings.

If funds are available in 1960, the statistical work on this study can be completed. It is hoped that this study will produce risk factors and show the effect of changed protection on accident rates of crossings where the protection has been upgraded.

This is a progress report, submitted as information. Your committee recommends that the assignment be continued.

Report on Assignment 4

Relative Effective Visibility of Highway–Railway Crossbuck Signs of Various Sizes, Colors and Materials

T. M. Vanderstempel (chairman, subcommittee), G. B. Blatt, A. C. Cayou, H. B. Clarkson, F. C. Cunningham, P. J. Harnish, C. I. Hartsell, W. H. Huffman, R. L. Lemon, J. F. Mark, H. L. Michael, W. C. Pinschmidt.

During the winter of 1958–59, tests were carried out with various finishes of highway–railway crossbuck signs on the General Motors Proving Ground at Milford, Mich. A total of 27 crossbucks, both of the 4-ft, 90-deg, and 6-ft, 50-deg types were erected. They were placed along a 1-mile road at regulation height and distance from the roadway edge.

The tests attempted to determine their visibility during the hours of daylight and during the hours of darkness. The night visibility was determined by visual observation and confirmed by means of photography.

Of the finishes of the 27 crossbucks referred to above, two were selected as being outstanding both for daylight and night observation. These finishes were then subjected to an additional test during the hours of daylight and darkness when the regular legend "Railroad Crossing" was replaced by a black stripe through the center of the 9-in blades of the crossbuck, the striping being one-third of the total width, or 3 in wide. When this test was carried out at night, an artificial rain was produced in order to determine whether this would effect the visibility of the finishes involved. The committee making this inspection decided that although two finishes were considered outstanding, further weathering tests should be carried out.

Your committee will carry out these tests in a highly industrialized area with a predominent presence of smoke and soot, and recommends that the assignment be continued.

Report on Assignment 8

Recommended Protection at Highway–Railway Grade Crossings Where One-Way Traffic on the Highway Crosses One or More Tracks on the Railway

Collaborating with Signal Section, AAR

D. W. Hughes (chairman, subcommittee), W. S. Autrey, G. B. Blatt, A. C. Cayou, P. J. Harnish, Wm. J. Hedley, W. H. Huffman, J. E. K. Krylow, J. F. Mark, H. L. Michael, E. S. Miller, R. J. Pierce, W. C. Pinschmidt, T. M. Vanderstempel, Maro Johnson, V. R. Walling.

A final report on this assignment was published in Bulletin 546, pages 249 to 258, incl. (Proceedings, Vol. 60, 1959). This report recommended for adoption and publication in the Manual a series of drawings showing signal aspects designed to provide basic minimum protection at highway–railway crossings for one-way highway traffic. Due to circumstances beyond the control of your committee, this report was not presented at the 1959 convention. All difficulties have now been resolved, however, and your committee now submits the following as a final report with recommendations for adoption and publication in the Manual.

The plans published in Bulletin 546 have been revised to show a space between the ends of the automatic crossing gates. These plans have the approval of both Committee 9 and the Signal Section, AAR, so far as the signal aspects are concerned.

The revised plans, designated as Figs. 3A to 3J, incl., (excluding Fig. 3I), are presented herewith with the recommendation that they be adopted and published in the Manual as pages 9–3–6.1 to 9–3–6.9, incl., as a guide for various authorities in protecting highway-railway grade crossings where one-way traffic on the highway crosses one or more tracks on the railway. Local conditions, the laws of the various states, policies of the various highway authorities, and the individual railways may require additional features not indicated on the plans.

In connection with the adoption of the aforementioned plans, your committee recommends revision of certain other material in Chapter 9, as presented below:

Page 9–3–1

RECOMMENDED USE OF HIGHWAY–RAILWAY GRADE CROSSING SIGNALS

In the second column of the table, at the end of the item reading "Cantilever flashing-light signal, as shown on pages 9–3–12 or 9–3–13", add the words "located as shown on pages 9–3–6.2, 9–3–6.3, 9–3–6.5, 9–3–6.6 and 9–3–6.7."

To the corresponding item in the third column add the following page numbers: 9–3–6.2, 9–3–6.3, 9–3–6.5, 9–3–6.6 and 9–3–6.7.

Pages 9–3–2 and 9–3–3

REQUISITES FOR HIGHWAY GRADE CROSSING SIGNALS

On page 9–3–2, add the following to the paragraph under Art. 1. Purpose: "for one-way or two-way traffic."

On the same page, add the following to the paragraph under Art. 2. Aspect: "except that back-to-back lamp units may not be required for one-way highway traffic."

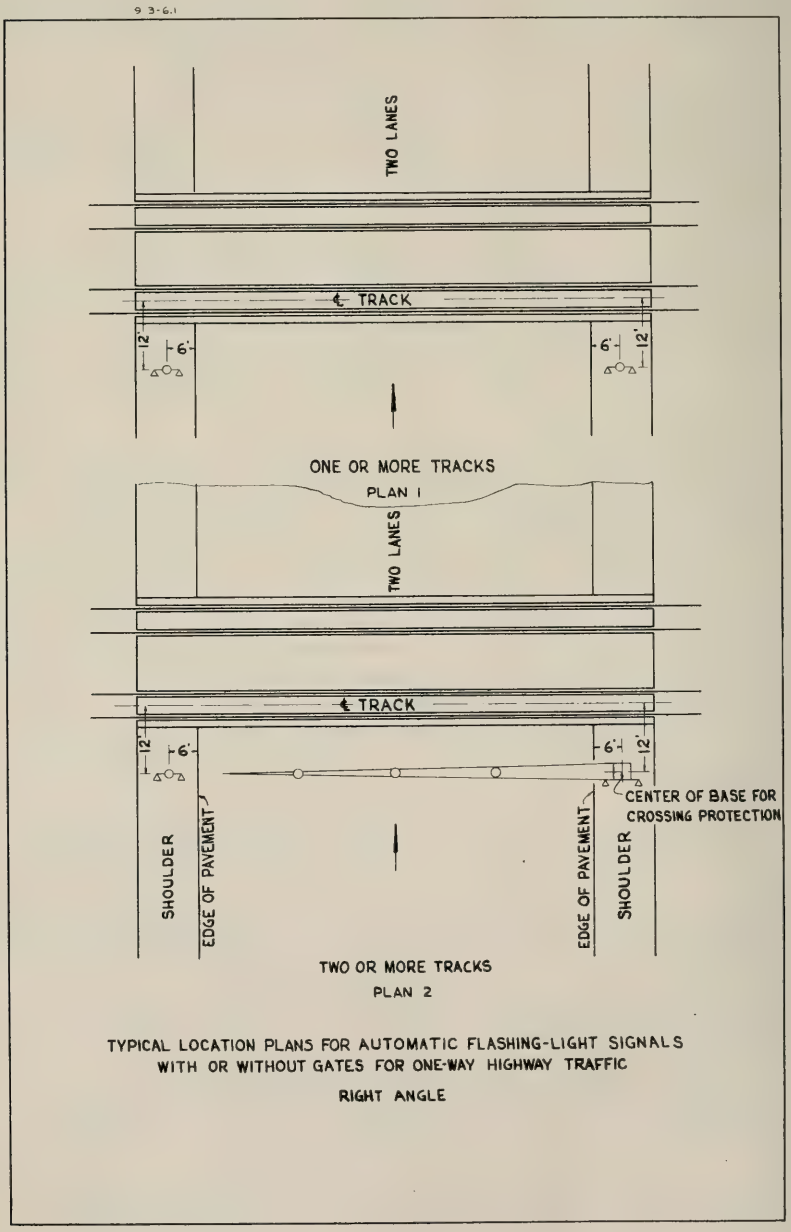

9 3-6.1
TWO LANES
℄ TRACK
12'
6'
6'
12'
ONE OR MORE TRACKS
PLAN 1
TWO LANES
℄ TRACK
12'
6'
6'
12'
CENTER OF BASE FOR
CROSSING PROTECTION
SHOULDER
EDGE OF PAVEMENT
EDGE OF PAVEMENT
SHOULDER
TWO OR MORE TRACKS
PLAN 2
TYPICAL LOCATION PLANS FOR AUTOMATIC FLASHING-LIGHT SIGNALS
WITH OR WITHOUT GATES FOR ONE-WAY HIGHWAY TRAFFIC
RIGHT ANGLE

Fig. 3A

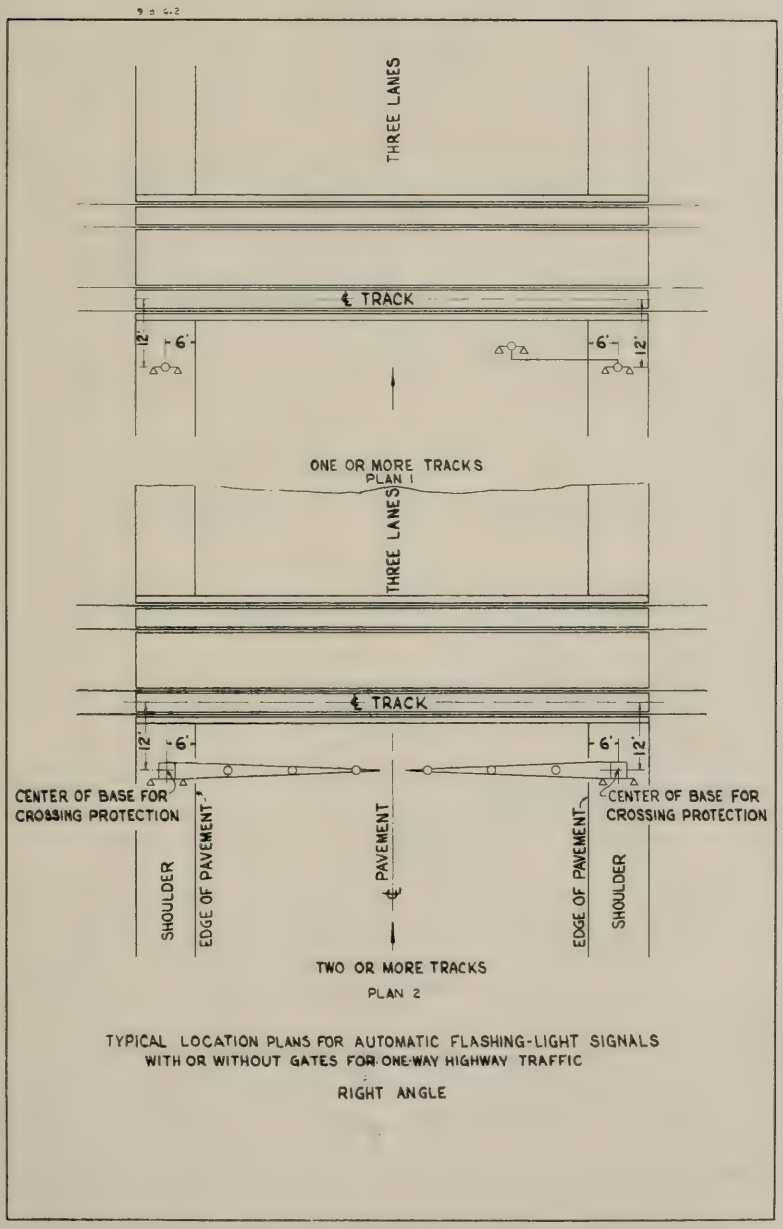

THREE LANES
℄ TRACK
12'
6'
6'
12'
ONE OR MORE TRACKS
PLAN 1
THREE LANES
℄ TRACK
12'
6'
6'
12'
CENTER OF BASE FOR CROSSING PROTECTION
CENTER OF BASE FOR CROSSING PROTECTION
SHOULDER
EDGE OF PAVEMENT
PAVEMENT
℄
EDGE OF PAVEMENT
SHOULDER
TWO OR MORE TRACKS
PLAN 2
TYPICAL LOCATION PLANS FOR AUTOMATIC FLASHING-LIGHT SIGNALS
WITH OR WITHOUT GATES FOR ONE-WAY HIGHWAY TRAFFIC
RIGHT ANGLE

Fig. 3B

A

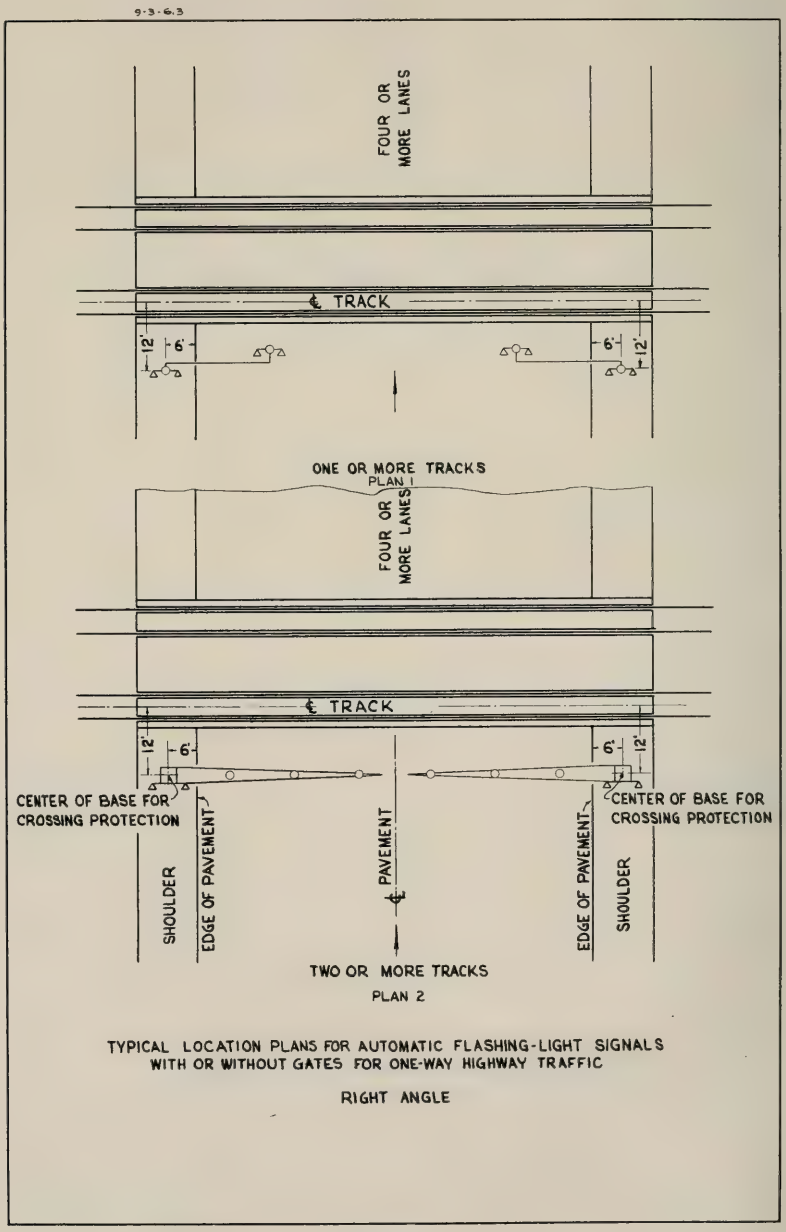

9-3-6.3
FOUR OR MORE LANES
℄ TRACK
12'
6'
6'
12'
ONE OR MORE TRACKS
PLAN 1
FOUR OR MORE LANES
℄ TRACK
12'
6'
6'
12'
CENTER OF BASE FOR CROSSING PROTECTION
CENTER OF BASE FOR CROSSING PROTECTION
SHOULDER
EDGE OF PAVEMENT
PAVEMENT
EDGE OF PAVEMENT
SHOULDER
TWO OR MORE TRACKS
PLAN 2
TYPICAL LOCATION PLANS FOR AUTOMATIC FLASHING-LIGHT SIGNALS
WITH OR WITHOUT GATES FOR ONE-WAY HIGHWAY TRAFFIC
RIGHT ANGLE

Fig. 3C

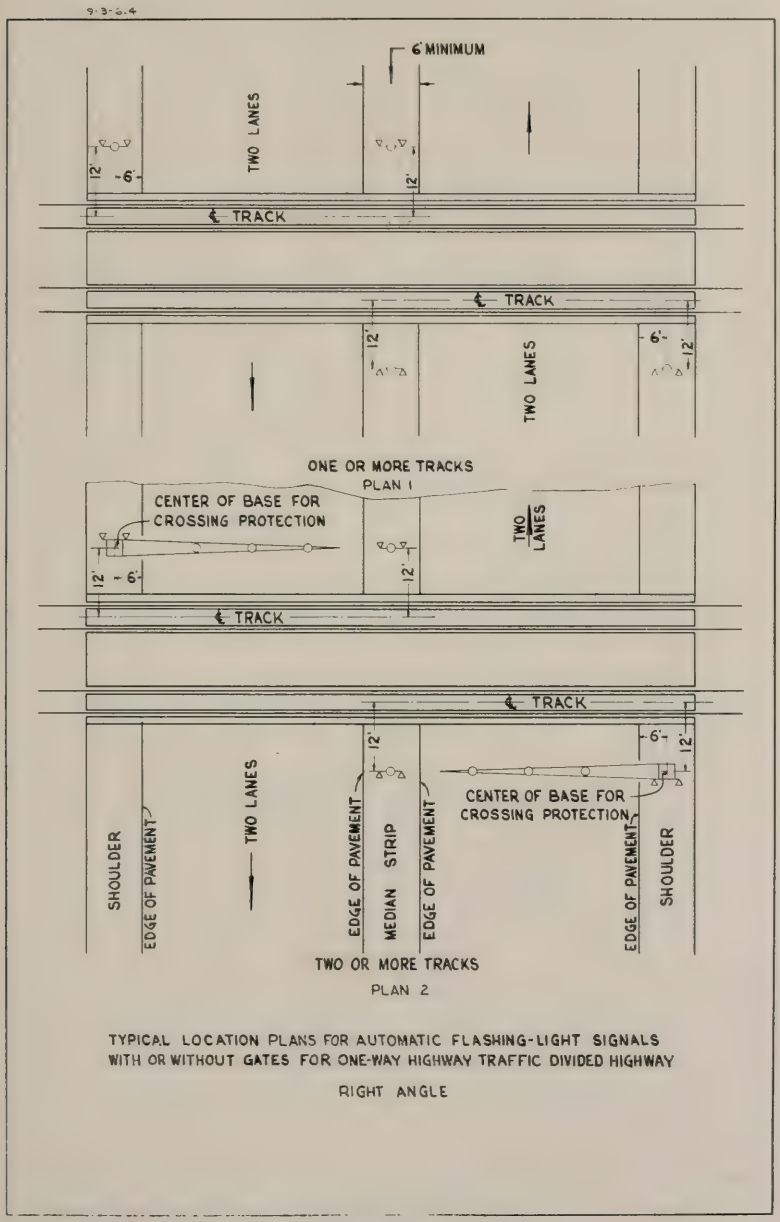
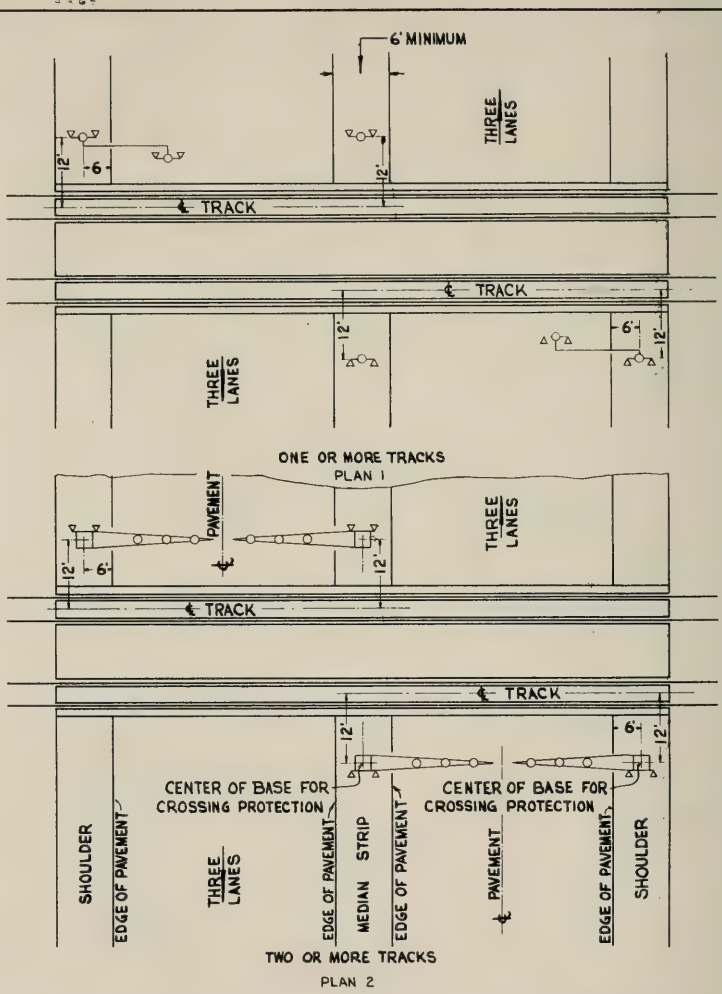

9-3-6.4
6' MINIMUM
TWO LANES
12'
6'
12'
℄ TRACK
℄ TRACK
12'
6'
12'
TWO LANES
ONE OR MORE TRACKS
PLAN 1
CENTER OF BASE FOR
CROSSING PROTECTION
TWO
LANES
12'
6'
12'
℄ TRACK
℄ TRACK
12'
6'
12'
CENTER OF BASE FOR
CROSSING PROTECTION
SHOULDER
EDGE OF PAVEMENT
TWO LANES
EDGE OF PAVEMENT
MEDIAN STRIP
EDGE OF PAVEMENT
EDGE OF PAVEMENT
SHOULDER
TWO OR MORE TRACKS
PLAN 2
TYPICAL LOCATION PLANS FOR AUTOMATIC FLASHING-LIGHT SIGNALS
WITH OR WITHOUT GATES FOR ONE-WAY HIGHWAY TRAFFIC DIVIDED HIGHWAY
RIGHT ANGLE

Fig. 3D



TYPICAL LOCATION PLANS FOR AUTOMATIC FLASHING-LIGHT SIGNALS WITH OR WITHOUT GATES FOR ONE-WAY HIGHWAY TRAFFIC DIVIDED HIGHWAY

RIGHT ANGLE

Fig. 3E

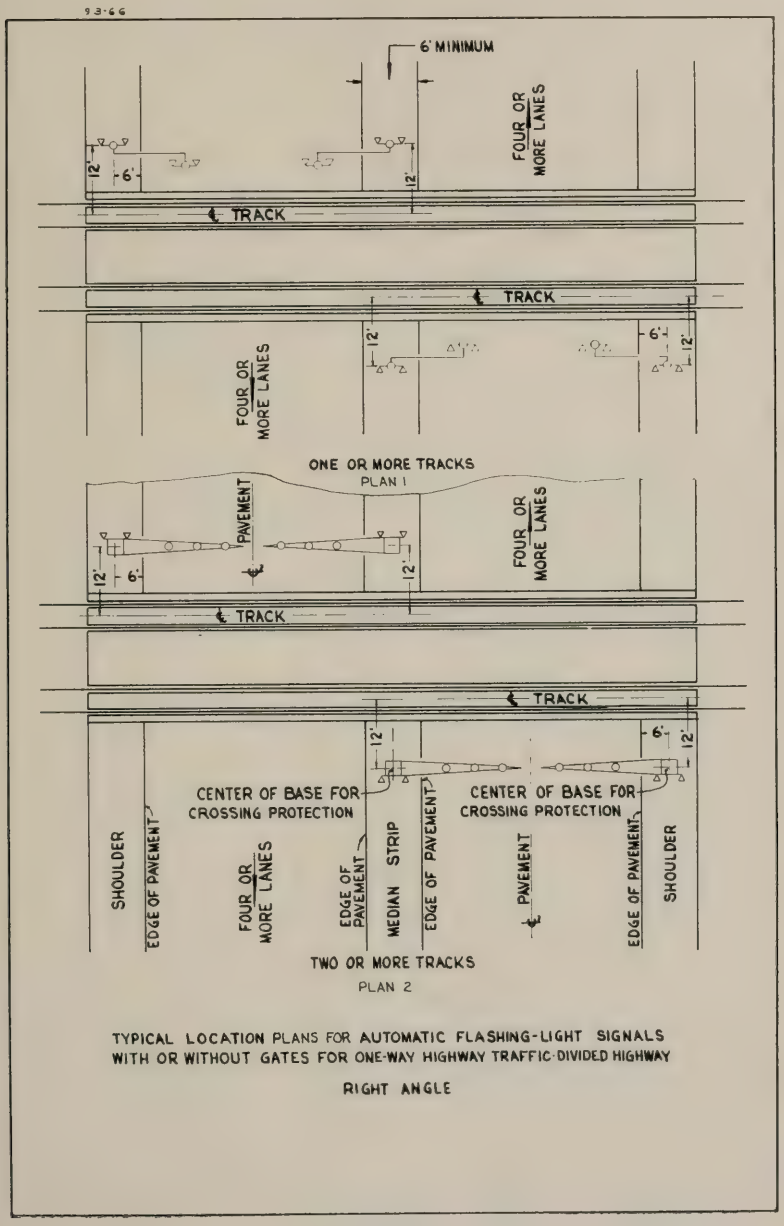
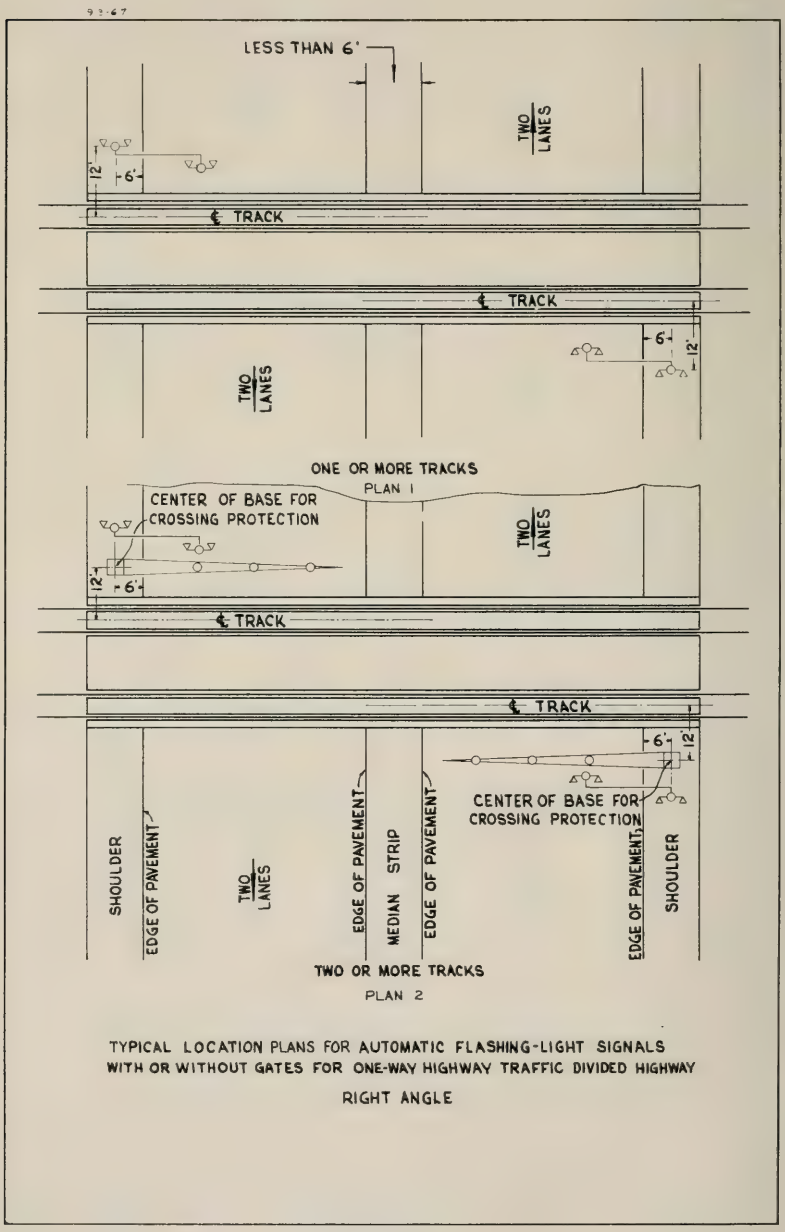

93-66
6' MINIMUM
FOUR OR MORE LANES
12'
6'
12'
TRACK
TRACK
FOUR OR MORE LANES
12'
6'
12'
ONE OR MORE TRACKS
PLAN 1
PAVEMENT
FOUR OR MORE LANES
12'
6'
12'
TRACK
TRACK
12'
6'
12'
CENTER OF BASE FOR CROSSING PROTECTION
CENTER OF BASE FOR CROSSING PROTECTION
SHOULDER
EDGE OF PAVEMENT
FOUR OR MORE LANES
EDGE OF PAVEMENT
MEDIAN STRIP
EDGE OF PAVEMENT
PAVEMENT
EDGE OF PAVEMENT
SHOULDER
TWO OR MORE TRACKS
PLAN 2
TYPICAL LOCATION PLANS FOR AUTOMATIC FLASHING-LIGHT SIGNALS
WITH OR WITHOUT GATES FOR ONE-WAY HIGHWAY TRAFFIC-DIVIDED HIGHWAY
RIGHT ANGLE

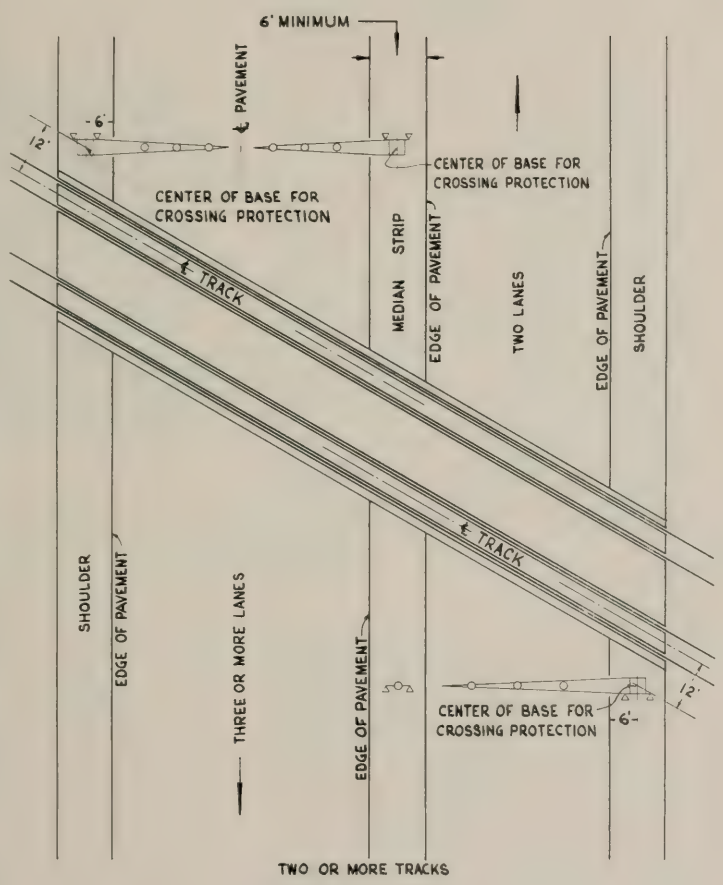
Fig. 3F



TYPICAL LOCATION PLANS FOR AUTOMATIC FLASHING-LIGHT SIGNALS WITH OR WITHOUT GATES FOR ONE-WAY HIGHWAY TRAFFIC DIVIDED HIGHWAY

RIGHT ANGLE

Fig. 3G



TYPICAL LOCATION PLAN (COMPOSITE) FOR AUTOMATIC FLASHING LIGHT SIGNALS AND GATES FOR ONE-WAY HIGHWAY TRAFFIC DIVIDED HIGHWAY
NOTE - FOR FLASHING LIGHT SIGNALS ONLY SEE FIG. 3A, 3B, 3D, 3E, AND 3G

ACUTE ANGLE
PLAN

Fig. 3H

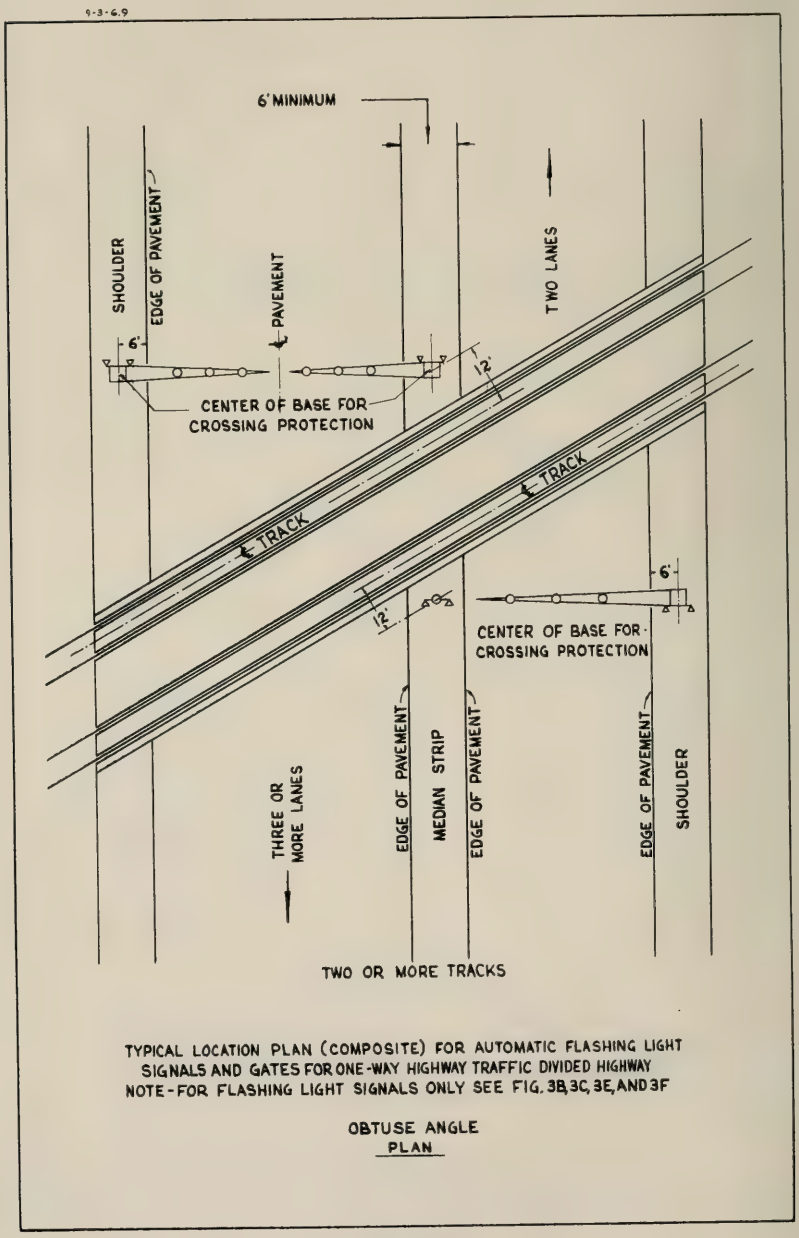

9-3-6.9
6' MINIMUM
SHOULDER
EDGE OF PAVEMENT
PAVEMENT
TWO LANES
6'
12'
CENTER OF BASE FOR CROSSING PROTECTION
TRACK
TRACK
12'
6'
CENTER OF BASE FOR CROSSING PROTECTION
THREE OR MORE LANES
EDGE OF PAVEMENT
MEDIAN STRIP
EDGE OF PAVEMENT
EDGE OF PAVEMENT
SHOULDER
TWO OR MORE TRACKS
TYPICAL LOCATION PLAN (COMPOSITE) FOR AUTOMATIC FLASHING LIGHT SIGNALS AND GATES FOR ONE-WAY HIGHWAY TRAFFIC DIVIDED HIGHWAY
NOTE-FOR FLASHING LIGHT SIGNALS ONLY SEE FIG. 3B, 3C, 3E, AND 3F
OBTUSE ANGLE
PLAN

Fig. 3J

Report of Committee 13—Water, Oil and Sanitation Services

D. C. Teal, *Chairman,*
E. C. Harris,
Vice Chairman,
T. L. Hendrix, Jr.,
Secretary,

R. C. Archambeault
W. F. Arksey
R. C. Bardwell (E)
R. A. Bardwell
R. O. Bardwell
V. C. Barth
J. M. Bates
M. R. Bost
I. C. Brown
T. W. Brown
P. J. Calza
V. R. Copp
R. E. Coughlan
B. W. De Geer (E)
C. E. De Geer
D. E. Drake
J. J. Dwyer
C. E. Fisher
R. S. Glynn
H. E. Graham
T. L. Gray
T. W. Hislop, Jr.
H. M. Hoffmeister
A. W. Johnson
C. O. Johnson
J. J. Laudig
H. L. McMullin
G. F. Metzdorf
C. F. Muelder
E. T. Myers
J. Y. Neal
John Norman
A. B. Pierce (E)
J. C. Roberts
N. B. Roberts
J. P. Rodger
E. R. Schlaf
H. M. Schudlich
H. E. Silcox (E)
R. M. Stimmel
T. A. Tennyson, Jr.
A. G. Tompkins
H. W. Van Hovenberg (E)
C. B. Voitelle
E. M. Walters
J. E. Wiggins, Jr.

Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, including outline of the work scheduled for next year .... page 284

2. Prevention of corrosion in hot and cold water systems.
   Report on Corrosion Prevention in Steam and Condensate Lines, submitted for adoption and publication in the Manual ..... page 285

3. Design, construction and operation of coach-servicing facilities to comply with regulations of U. S. Public Health Service, collaborating with Joint Committee on Railway Sanitation, AAR.
   Brief report of progress, presented as information ..... page 291

4. Cathodic protection of pipelines and steel storage tanks, collaborating with the Electrical Section, AAR.
   No report for publication. The report prepared by the subcommittee has not yet been approved by the collaborating organization.

5. Transportation of solids by pipelines, collaborating with the Pipeline Division, ASCE, and other interested organizations.
   Final report, submitted as information ..... page 292

6. Railway waste disposal, collaborating with Joint Committee on Railway Sanitation, AAR.

   Previous reports on this subject have been condensed into a statement of recommended practice which is presented this year as information, looking to considering it next year for inclusion in the Manual ..... page 292

7. Inspection and maintenance of diesel fuel oil storage tanks.

   Progress report, submitted as information, with the idea that it will be considered next year for inclusion in the Manual ..... page 294

8. Methods of controlling spillage of fuel oil at diesel fueling and unloading stations.

   Progress report, submitted as information ..... page 296

9. Disinfectants, deodorants, fumigants and cleaning materials, collaborating with Joint Committee on Railway Sanitation, AAR.

   No report for publication. The draft prepared by the subcommittee this year will be revised and submitted next year.

10. Railroad aspects of radioactive substances, collaborating with Joint Committee on Railway Sanitation, AAR.

    The committee is keeping abreast of developments in this field, but at this time has nothing significant to add to its report of last year.

11. Methods of heating fuel oil to permit winter-time use of high-pour-point "economy" grade fuel oil.

    Final report, submitted as information ..... page 301

12. Plastic pipe and its uses on railroads.

    Final report, submitted as information ..... page 303

THE COMMITTEE ON WATER, OIL AND SANITATION SERVICES,
D. C. TEAL, *Chairman.*

AREA Bulletin 553, November 1959.

Report on Assignment 1

Revision of Manual

E. C. Harris (chairman, subcommittee), W. F. Arksey, R. C. Bardwell, I. C. Brown, R. E. Coughlan, T. L. Hendrix, T. W. Hislop, A. W. Johnson, C. F. Muelder, A. B. Pierce, J. C. Roberts, E. R. Schlaf, H. M. Schudlich, C. B. Voitelle, J. E. Wiggins.

No Manual revisions are proposed for this year. The committee plans to review Parts 5, 6 and 7 of Chapter 13 during 1960, giving particular attention to the documents mentioned below.

13–5–10 and 13–5–11
SPECIFICATIONS FOR SALT TO BE USED IN REGENERATION OF ZEOLITE WATER SOFTENING PLANTS

It is planned to revise the specification for salt so they will be more stringent in regard to allowable insoluble impurities. The impurities now allowed by the specifications have caused enough trouble with the operations of automatic zeolite water-treating plants to justify this action.

Pages 13–6–1 to 13–6–10, incl.

WATER ANALYSIS AND INTERPRETATION OF RESULTS

The practice described on page 13–6–1 for reporting mineral constituents of water in hypothetical combinations is to be revised to include other accepted methods of reporting these results.

Instead of showing specific details for preparing certain standard solutions (pages 13–6–2 to 13–6–4, incl.) the committee will propose the listing of accepted reference books wherein the preparation of each reagent can be found in detail.

The committee proposes to revise the entire section on rapid field tests, beginning on page 13–6–4, bringing it up to date.

Pages 13–7–1 and 13–7–2

Part 7—Characteristics of Water

This entire Part will be brought up to date to conform with the times of the diesel locomotive.

Report on Assignment 2

Prevention of Corrosion Hot and Cold Water Systems

J. J. Dwyer (chairman, subcommittee), R. C. Archambeault, R. A. Bardwell, I. C. Brown, T. W. Brown, H. E. Graham, E. C. Harris, C. F. Muelder, E. T. Myers, R. M. Stimmel, A. G. Tompkins, E. M. Walters.

Final Report on Prevention of Corrosion in Steam and Condensate Lines

Corrosion damage in steam and condensate lines has amounted to millions of dollars each year. New chemical methods of combatting these losses and protecting steam systems against the destructive nature of untreated condensate have been recently developed. These new developmnts in extending condensate-line life were reported as information to the Association in 1959, under Assignment 2, then called "Prevention of Corrosion in Steam and Condensate Lines."

The report was so well received, both by the railroads and outside industries, that it was considered by your committee as being a valuable source of information for railroads' use in protecting their properties against this particular type of metal deterioration. Further investigation of installations utilizing the methods and chemical treatments described proved that satisfactory protection could be achieved which had not been possible previously.

Your committee decided, therefore, that the 1959 Assignment 2 report should be restudied and redeveloped in a condensed form containing the basic principles and information necessary for use as a recommended practice by the railroads, instead of beginning work on the 1960 Assignment 2—Prevention of Corrosion in Hot and Cold Water Systems. The condensed report, designated as "Corrosion Prevention in Steam and Condensate Lines," is now submitted as a final report with the recommendation that it be adopted and published in the Manual at the end of Part 4—Water Treatment.

CORROSION PREVENTION IN STEAM AND CONDENSATE LINES

Corrosion damage in steam and condensate line systems amounts to several million dollars each year. Methods of combatting these losses are outlined below. The subject is covered in two sections: the nature of the problem involved, including mechanical and design considerations, and the chemical treatments, including use of volatile chemicals in the steam to neutralize acids or to form a film barrier on metal surfaces.

A. NATURE OF PROBLEM AND DESIGN ASPECTS

1. Chemical

Steam condensate presents a serious problem in piping maintenance because it is generally of a corrosive nature and highly aggressive to many piping materials. The greatest danger stems from the deleterious gases which the condensate has absorbed. Of these, dissolved oxygen and carbon dioxide account for practically all of the corrosion found in condensate lines.

Carbon dioxide is generally the primary cause of return-line corrosion. The major portion of this gas in the steam cycle results from the decomposition of bicarbonate or carbonate contents of the boiler feedwater. Because of this breakdown taking place in the boiler, carbon dioxide is always present in steam, unless the feedwater is pure distilled water or equal. When steam condenses, the carbon dioxide is absorbed by the condensate and forms carbonic acid, which is aggressive to both the ferrous and nonferrous metals found in return systems. Concentrations of 5 ppm or less are not usually troublesome, unless large amounts of steam are involved.

Dissolved oxygen present in aqueous solutions containing carbon dioxide has been found to produce a corrosive environment 2 to 10 times more severe than would occur with carbon dioxide only. A corrosive attack caused by dissolved oxygen can be identified usually by a pitting of the metal surface, with the pits being wholly or partially filled with corrosion products. These nodules of corrosion products consist of a hard crust, under which exists black magnetic ferrous oxide or red ferric oxide.

Steam condensate lines fail most often at threaded joints. Systems of pipes of dissimilar metals will greatly intensify the rate of corrosion. Horizontal lines usually will be found more severely damaged than vertical lines, because the acid condensate practically lies in the pipe. The corrosion damage will be found mostly in the form of channeling or grooving of the bottom of the pipe due to carbonic acid, but pitting and oxide accumulations can be observed when oxygen is present. Fittings may be found to contain large accumulations of iron oxide deposits, which when removed will show little or no damage to the fittings themselves. This would indicate that the corrosion is taking place elsewhere in the system, converting the iron bicarbonate to ferrous hydroxide and on to ferric hydroxide, which precipitates and settles at points of poor circulation. Examples may be found in which the damage is due primarily to grooving, or primarily to pitting, or to combinations of both

2. Mechanical

Good mechanical deareation and chemical treatment of feedwater are essential for oxygen-free steam. Faulty traps, vents, valves, packing glands of vacuum pumps, and injection of cold water are sources for oxygen being drawn into a condensate system. In the case of cold-water injection into condensate lines to lower temperatures and improve efficiency of condensate pumps, another type of failure, described as cavitation, may occur. The cold water causes instantaneous collapse of the steam in the line, creating shock forces sufficiently great to cause destruction of the pipe by cavitation effect. It may be detected by hammering or banging sounds in the condensate pipe.

Good mechanical design is most important to return-line installations. Slope of horizontal pipes and joints between dissimilar metals should receive special attention, as outlined in the recommendations below. The best quality of corrosion resistant piping material, consistent with economic limitations, should be used. Extra strong wall pipe and fittings are recommended for longest life. The mechanical and design features may be summarized as follows:

a. Feedwater deaerators must be operated at or above 212 deg F, and maintained in efficient condition. The minimum operating temperature must be that of boiling water at the designed operating pressure, which may be from 0 to 40 psi, depending on the type of deaerator.
b. ASA Schedule 80 or extra strong wall pipe and fittings should be used in condensate return lines.
c. Condensate line pipe should be reamed to remove burrs.
d. All horizontal return lines should have a slope of at least 4 in per 100 ft.
e. All low points or pockets in lines where condensate could collect should be eliminated or properly trapped.
f. All joints in return lines operating under less than atmospheric pressures should be air tight.
g. Insulating fittings should be used to connect dissimilar metals in the condensate system.
h. Cold water injection into return lines ahead of vacuum pumps should be avoided.

B. CHEMICAL TREATMENT

1. Types of Treatment

Good design, construction, and operation of steam condensate return systems are quite important, but by themselves are not sufficient to reduce maintenance costs to the minimum obtainable through the supplementary use of chemical treatment. The additional measures which may be utilized to extend maintenance savings are as follows:

a. Treatment of boiler feedwater to eliminate dissolved gases.
b. Injection of chemicals into the steam that will carry along with the steam to neutralize any corrosive substances present (neutralizing amines).
c. Use of film-forming chemicals in the condensate system to prevent contact between the condensate and the metal surfaces (filming amines).

Item a. is a requisite of good boiler operating practice and is therefore outside the scope of this report. It is assumed that good boiler-feedwater treatment must include the use of oxygen scavengers, such as sodium sulfite or hydrazine, to insure that steam leaving the boiler will be oxygen free. Items b. and c. are newer developments, and are described in turn below.

2. Neutralizing Amines

Ammonia was the first volatile nitrogen compound to be used for neutralizing carbonic acid, to increase pH, and to reduce corrosion of ferrous metals. Copper- and zinc-bearing metals are rapidly corroded by ammonia, however, especially when oxygen is present. If the feedwater is not completely deaerated, therefore, ammonia requirements may be high, with correspondingly greater hazards to copper and zinc constituents. For these reasons ammonia is now seldom used in this capacity.

The better known neutralizing amines are cyclohexylamine, benzylamine, and morpholine. They are much less aggressive to copper- and zinc-bearing alloys, and have other protective characteristics superior to ammonia. They do not protect against oxygen; their primary function is to neutralize carbonic acid in the system. They are applied in direct proportion to the amount of acid present, and requirements and costs, therefore, could become high. They thus find their best application in systems with low makeup and low carbon-dioxide content. Treatment is usually based on the amounts of these neutralizing amines needed to raise the condensate pH to 7.0 or slightly over.

The ratio of amine in the steam to that dissolved in the condensate is called its distribution ratio. It will be noted in the accompanying Summary of Characteristics table that the ratio for ammonia is at least 7 to 1, or very poor, and for morpholine is 0.4 to 1, or very good, considering that the treatment objective is to get the amine out of the steam and into the condensate to neutralize the acid present. Cyclohexylamine volatilizes from boiling water at lower temperatures than morpholine, so it is favored for low-pressure systems. For systems operating above 50 psi, morpholine is better.

In feeding neutralizing amines, slug feed methods are most common, but least desirable because of the expensive nature of these chemicals. The most efficient and economical dosages are obtained by proportioning continuous-feed methods. They can be added to the chemical vat with phosphate and/or alkaline salts and fed to the boiler in proportion to the makeup required.

All three of these amines are skin irritants and should be handled accordingly. At the dosages used, however, they are not toxic in the steam, and the cendensate will not

SUMMARY OF CHARACTERISTICS

Ammonia	Cyclohexylamine	Benzylamine	Morpholine
(a) Distribution Ratios (parts in steam per part in condensate):			
7-10	2-4	3-4	0.4
(b) Dosages to adjust pure water to pH 9.0:			
0.2-0.5 ppm in water 1.4-2.0 ppm in steam	2.0 ppm in water 4-8 ppm in steam	2.2 ppm in water 6-8 ppm in steam	4.0 ppm in water 1.6 ppm in steam
(c) Dosages to neutralize condensate to pH 7.0:			
	3.0 ppm(60%) /ppm CO_2	2.2 ppm/ppm CO_2	1.6 ppm/ppm CO_2
(d) Neutralizing value (dosage to bring water containing 10 ppm CO_2 to pH 7.4):			
	20 ppm	22.05 ppm	19.8 ppm
(e) pH of dilute solution of amine bicarbonate:			
	8.1	7.8	7.4
Concentrates excessively. May attack copper, brass. Has high alkalinity suitable for all-iron system. Requires excessive amounts in steam to get adequate pH of condensate.	Compounds with CO_2 do not hydrolyze freely. High alkalinity tends to prevent CO_2 removal, increases percent recirculation and CO_2 concentration. Readily lost during deaeration and at vent. Low losses in blowdown. Minimum attack on copper and brass. Small loss of CO_2 from compounds causes large pH increase. Amine bicarbonates can cause plugging.	Intermediate in alkalinity between cyclohexylamine and morpholine. Causes some recirculation of CO_2. Moderate losses, blowdown and deaeration. Intermediate CO_2 removal from system. Has pungent odor.	Lower alkalinity allows CO_2 removal in feedwater heater. Lower volatility, so greater blowdown losses. Concentration decreases during distribution of steam at low pressure (5 psig and less). No attack on copper or brass. Large CO_2 release has minimum effect on pH. No plugging (morpholine bicarbonate very soluble)

cause intestinal disturbances. Nevertheless, if they are to be used in steam for direct cooking or processing of food, it would be wise to study the medical aspects and Food and Drug Administration views on the particular application involved.

Analytical methods of dosage control may be by means of standard pH meter, modified colorimetric pH methods, actual titration of dissolved carbon dioxide, or colorimetric determination of the neutralizing amine content, using a copper salt which forms a characteristic blue color from the presence of a copper-amine complex, the strength of the blue color being proportional to the amount of amine in solution. In addition to analytical methods, field-test corrosion devices inserted in condensate lines are used to measure the extent of corrosion actually taking place.

3. Filming Amines

These inhibitors function by establishing a non-wettable film on metal surfaces in contact with the condensate. The film is mostly one molecule thick and does not tend to increase with continued treatment. Dosages required are only 1 to 3 ppm and are independent of carbon dioxide and oxygen concentrations, since the filming amines do not combine chemically with these corrodents.

The most effective filming inhibitors are saturated, straight-chain primary aliphatic amines and their salts, with chains of 10 to 18 carbon atoms. Octadecylamine and octadecylamine acetate are the most commonly used examples. They have a polar end which adsorbs to a metal surface, and a long water-insoluble carbon chain standing perpendicular to the metal. With continuous, uniform application rates they will pack so closely together that no metal surface will be left exposed to the condensate. Protection rates of 95 percent or better are thus possible.

Pure octadecylamine is insoluble in water, for which reason its water dispersible salt, octadecylamine acetate, has been generally used. This form is not compatible with hardness in water or with alkaline or neutral salts, so it cannot be fed with other water-treating chemicals; a separate chemical vat and mineral-free water are required. The dry flake acetate form is, however, readily dispersed in hot condensate to the recommended application solution strength of 1 percent. Such solutions have a pH of about 5.5, so chemical vats should preferably be corrosion resistant. Injection direct into steam lines may allow flashing and some hydrolysis to acetic acid, with minor corrosion of the chemical and steam line near the point of entry. This can be avoided by direct injection into the boiler, since free octadecylamine is then liberated and volatilizes with the steam. The acetate solutions should not be fed direct to superheated-steam systems or ahead of pressure-reducing valves, to avoid formation of amine-acetamides, which cause deposits and are poor inhibitors.

An improvement over the octadecylamine acetate is an upgraded or super-filming amine, utilizing straight octadecylamine with an emulsifier, which is also a filming amine. It contains up to 31 percent more active ingredient than commercial-grade octadecylamine acetate. It is available as a 20-percent emulsion and in a dry flake form. Both forms are 100 percent self dispersing. One-percent solutions contain no acetate or acetic acid, and have a minimum pH of 9.0, eliminating corrosion hazards to vats and piping. They may be fed to boilers or steam headers. They are compatible with moderate amounts of hardness and water-treating chemicals, but where injected into steam lines, only condensate is recommended as the solvent to avoid deposits. This pure octadecylamine form is recommended over the acetate form.

Another property of the filming amines is to displace and remove corrosion products. This cleaning action on metal surfaces improves heat-transfer rates in heat exchangers and condensing equipment. These deposits should not be removed too rapidily, however,

or they may clog traps and strainers. For this reason it is best to start treatment at only about one-fourth ultimate strength, and allow at least three months to gradually increase the formula to the desired concentration.

The filming amines, to be successful, must be fed to boilers or steam lines continuously and at uniform rates. A proportioning chemical pump is therefore required. Handling and use precautions are similar to those described for the neutralizing amines, and should be observed in accordance with manufacturers' directions. As an example of the benefits which may be achieved, severe corrosive conditions in an untreated system might produce up to 100 ppm iron in the condensate, but effective control by filming amines should limit the iron to less than 1 ppm. Several means are available for evaluating the corrosion-control progress of the filming-amine treatment. These, and the principal advantages of the filming amines, may be summarized as follows:

a. They may be applied in low, economical dosages, effectively to control corrosion in condensate systems and on condensing surfaces, with considerable savings in maintenance.
b. Dosages required are independent of concentrations of dissolved gases.
c. Both oxygen and carbon dioxide are controlled.
d. They increase heat-transfer rates by removing deposits and by promoting dropwise condensation.
e. Optimum results are obtained by continuous application in the range of 1 to 3 ppm.
f. Efficiency of treatment may be checked by NDHA* or other corrosion testers inserted in the condensate system.[1]
g. It may be checked by analytical determinations of dissolved iron in the condensate.
h. Colorimetric laboratory and field-test methods are available for determinations of residual amine in the steam.[2, 3]

The test method entitled Determination of Octadecylamine[2] is simple and convenient to use for treatment-control purposes. It furnishes a quantitative estimation of the octadecylamine presented in condensed steam. After acidifying the sample with hydrochloric acid, chloroform is used to extract the amine. Addition of a 0.4-percent aqueous solution of bromophenol blue indicator colors the chloroform layer a light yellow in direct proportion to the octadecylamine concentration.

Specifications for procurement of filming amines should include a minimum active-inhibitor content in order to obtain an equivalent basis for cost comparisons and dosage calculations. Suppliers should be required to specify the percentage of primary amine in the products being furnished.

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* National District Heating Association.

[1] Corrosivity Test of Industrial Water, ASTM Designation D 935–49.

[2] Determination of Octadecylamine, J. F. Wilkes, 1029 W. 35th St., Chicago 9, Ill.

[3] Determination of Amine Nitrogen, ASTM Committee D–19 Tentative Method.

Report on Assignment 3

Design, Construction and Operation of Coach-Servicing Facilities to Comply with Regulations of U. S. Public Health Service

Collaborating with Joint Committee on Railway Sanitation, AAR

J. C. Roberts (chairman, subcommittee), R. C. Archambeault, J. M. Bates, M. R. Bost, T. W. Brown, V. R. Copp, D. E. Drake, R. S. Glynn, H. E. Graham, T. L. Hendrix, Jr., A. W. Johnson, H. L. McMullin, C. F. Muelder, E. R. Schlaf, H. M. Schudlich, H. W. Van Hovenberg, J. E. Wiggins, Jr.

The following report of progress is offered as information:

The committee's basic interpretation of the Interstate Quarantine Regulations concerning coach-watering facilities is that hydrants with underground seepage bed drainage are prohibited for any new installation. Those using underground pipeline drains will be approved only where overhead water systems or hydrants of an approved type are not practical. In all cases plans for new or reconstruction of existing coach-watering facilities must be submitted to the Public Health Service for review and approval.

An inquiry circulated by the committee has developed that the majority of some 20,000 coach-watering hydrants now in use on the American railroads are considered unsatisfactory by the U. S. Public Health Service. The railroads are under more or less constant pressure from the U.S.P.H.S. to replace these with approved hydrants.

The committee's investigation also disclosed that the hydrants now approved by the U.S.P.H.S. are in most cases expensive to install and maintain, and are generally unsatisfactory so far as the railroads are concerned.

In progressing the assignment a mass of data has been collected, consisting of blueprints and pictures of coach-watering facilities now in use by various railroads over the country.

The development of a satisfactory coach-watering hydrant from the mass of data that has been collected requires time and application of engineering skills that the committee does not have at its command. Therefore, your committee, last June, referred this matter to the director of engineering research, AAR, proposing an allocation of $15,500 for a research project. This request has since been duly considered by the AREA Board of Direction and other organizations concerned, and the sum of $2000 has been recommended for inclusion in the 1960 AAR Research Budget for a preliminary study of the problem.

Report on Assignment 5

Transportation of Solids by Pipelines

Collaborating with the Pipeline Division, ASCE, and Other Interested Organizations

E. M. Walters (chairman, subcommittee), R. O. Bardwell, J. M. Bates, C. E. DeGeer, T. L. Gray, T. W. Hislop, Jr., J. J. Laudig, E. T. Myers, J. Y. Neal.

Your committee presents the following final report as information.

A report on the engineering design, construction and operation of the Gilsonite solids pipeline at Grand Junction, Colo., is given in the journal of the Pipeline Division, ASCE, for January, 1959. It covers the economic and engineering problems overcome in transporting a solid of the Gilsonite type.

Julian Nardi, in his article "Pumping Solids Through a Pipeline", Chemical Engineering, July 27, 1959, gives the background on what's been done, where and when, on this problem. He states that the points to consider in designing a solids pipeline are: (a) physical characteristics of the solid, (b) physical characteristics of the slurry, and (c) design data, all of which points will vary with the material, so that while general theories will apply, each installation will require individual research and development.

A solids pipeline may be feasible from an engineering standpoint, with no unusual problems, while economically it would not be worth considering. In many cases the cost of preparing the material for transportation and for use at the end of the line will be greater than transportation costs by other methods.

Mr. Nardi points out that a pipeline is more economical than the usual means of bulk transportation only when large quantities, many years of useful life, high annual load factor, and relatively long distances are involved. The two basic advantages involved are that a smaller portion of its operating costs are in labor and materials, and the cost of returning empty containers is eliminated.

Report on Assignment 6

Railway Waste Disposal

Collaborating with Joint Committee on Railway Sanitation, AAR

T. A. Tennyson (chairman, subcommittee), R. C. Archambeault, V. R. Copp, D. E. Drake, R. S. Glynn, C. O. Johnson, H. L. McMullin, G. F. Metzdorf, J. Y. Neal, N. B. Roberts, E. R. Schlaf, R. M. Stimmel, A. G. Tompkins, H. W. Van Hovenberg, J. E. Wiggins, Jr., A. B. Pierce.

The report of your committee for this year is a statement of recommended practice condensed from material previously developed. It is submitted as information, with the recommendation that it be published in the Manual after further consideration. It applies to industrial-type wastes that cause or contribute to pollution of public waters. It does not go into detail as to specific solutions, which are as numerous as the problems themselves, but shows generally what is needed to attack the problem of disposal of wastes from railroad property.

A. GENERAL

Since it is in the public interest to alleviate pollution of streams, lakes and other public waters, the control of industrial waste disposal has become an active matter in

federal and local government as well as interstate and international agreements. The railroads are mainly involved through their generation of industrial-type wastes in shop and yard areas where the major problem is in connection with the oil content of such wastes.

There is no simple solution generally applicable to all waste-disposal problems since each problem and location requires individual attention from a technical standpoint for its solution and control. This points to the need for an organization to handle waste disposal similar to the type of organization that handles water-treatment problems.

B. ORGANIZATION

An individual of adequate technical training, who is familiar with laboratory procedures and has supervisory ability, should be selected to handle waste-disposal problems. He should have an adequate staff, and the equipment and authority to do the job.

C. PRELIMINARY STEPS

In the approach to control of water pollution there are several basic factors which must be considered. Some of them are as follows:

1. Know the condition and flow of the receiving water.
2. Ascertain all applicable pollution-control requirements.
3. Know exactly what type and amounts of wastes are to be handled and their relation to regulations and local conditions to determine most economical approach.
4. Take any advantage indicated where one waste might neutralize another.
5. Contact control authority and prepare complete plans for disposal of the wastes.
6. Obtain formal approval of the plans, if required.
7. Prepare a complete description of the facilities for pollution control, including requirements that must be met and controls necessary, so that the personnel later charged with operating the facilities will understand the factors involved in the disposal of the wastes.

D. EVALUATION OF THE PROBLEM

In making plans for disposal of water-borne wastes the simple solution should not be overlooked. It may often be possible to meet pollution-control requirements by preventing mishandling and/or misuse of the materials which cause or contribute to the pollution of water. Floating solids as well as excessive amounts of readily settleable solids, alkalis and visible oil are prohibited in liquid wastes that are discharged to public waters. If at all possible an appropriate agreement should be negotiated that will grant permission to discharge such wastes into an existing municipal sewerage system or industrial waste-disposal facility.

1. Study sources of contaminants and attempt to reduce loss of fuel, lubricating oil, etc., as well as waste of cleaning materials.
2. Eliminate as far as feasible the use of cleaning and other materials which contain chemicals not acceptable in public waters in reasonable amounts.
3. Segregate polluted water from the main storm-water shop or yard drainage system. Where this cannot be done it may be necessary to run drainage to lagoons of sufficient size to hold storm runoff and provide means to have a constant rate of flow from the lagoons to oil-separation facilities.
4. If at all possible separate sanitary sewers from shop drainage.

E. DESIGN OF FACILITIES

Facilities for separation of oil and water, etc., are readily available commercially. They can also be designed from published data. With them the entire range of the problem can be handled, including separation of oil and water, neutralization of acid and alkaline wastes, separation of solids, and combinations of these. Methods of analysis and control are available in the literature.

F. OPERATION OF FACILITIES

Adequate control is necessary for proper operation of waste-disposal facilities, and the following practices are considered essential:

1. Cooperate with control agencies.
2. See that adequate laboratory controls are set up and used.
3. Sponsor regular discussion of waste-disposal problems.
4. Maintain adequate contact with current developments by reading published data, attending meetings, etc.

G. DISPOSAL OF MATERIAL REMOVED BY WASTE TREATMENT

Contaminating material removed from waste water must be disposed of in such a manner that it will not further contribute to the pollution problem. It may often be possible to reuse waste water as well as the waste oil separated from it. In case the oil cannot be reused, it must be burned or arrangements made to have it picked up by a scavenger. Solids should be dumped in such locations that they cannot get into streams or contaminate underground water supplies.

The solution of this portion of the problem will depend entirely on local conditions and should be thoroughly considered when waste-disposal facilities are planned.

REFERENCES

1. Water Pollution Abatement Manual (W1, W2, W3, W4, W5), Manufacturing Chemists' Association.
2. Manual on Disposal of Refinery Wastes (Vol. I, II, III, IV, V), American Petroleum Institute.
3. ASTM Standards, Part 10, 1958, American Society for Testing Materials.

Report on Assignment 7

Inspection and Maintenance of Diesel Fuel-Oil Storage Tanks

A. W. Johnson (chairman, subcommittee), V. C. Barth, M. R. Bost, P. J. Calza, C. E. DeGeer, John Norman, J. C. Roberts, C. B. Voitelle.

Your committee recommends the following procedure for maintaining diesel fuel oil storage tanks and is submitting it for consideration as Manual material next year.

Diesel fuel-oil tanks should be inspected at six-month intervals, spring and fall, primarily to determine the amount of water and sediment accumulated in the bottoms. This includes all tanks, regardless of size, located above ground or underground. The accumulation of water and sediment can ordinarily be removed from above-ground tanks by gravity through valved outlets near the tank bottom if the tank is so equipped. If there are no such outlets, water and some sediment can be removed by pumping through the opening in the top of the tank.

Fuel samples should be taken by a qualified inspector using an ASTM "tank thief," a sampling device having a cast aluminum case 4 in. in diameter by 12 in long, with a spring-actuated butterfly valve at the bottom. It is open at both ends when being lowered into the oil, and the butterfly valve can be closed at any level to take a sample; it closes automatically ⅛ in above the bottom. Usually, samples are taken at the half-full level and near the bottom for analysis and report. The report should include the pH value and the salinity of the water, as in a few cases it has been found that the water was acid or corrosive in nature and may cause the tank bottoms to corrode. Accumulation of water and sediment over a six-month period usually is negligible. A substantial amount indicates ground- or surface-water leakage into the tank. Above-ground tanks are less subject to such leakage and less expensive to maintain.

The seriousness of fire and explosion hazards in connection with working in and around tanks used for storage of diesel fuel oil is generally recognized. If tanks are emptied for inspection, cleaning or repairs, the interior should be thoroughly cleared of oil fumes by steaming or venting and then tested with an explosimeter. If this is not practical, men entering tanks must be equipped with air-pack breathing devices.

Inspection of tanks for general condition and determination of repairs needed should be made annually by division supervisory forces.

Service piping from tanks should be arranged so that the entire depth of fuel can be used or circulated to prevent its becoming too old, resulting in oxidation or enlargement of particle size which would cause filter stoppage or locomotive fuel-injector trouble. If the tank drain will not remove all water and sediment, a suitable inhibitor can be used to protect against corrosion of the bottom.

In addition to semi-annual and annual inspections of tanks to determine general conditions and need of repairs, there are several other items having a direct bearing on the condition of tanks which should be checked at the time of inspection, as follows:

1. Tanks and their surrounding areas should be clean and free of weeds, grass, paper and other combustible material. There should be good drainage away from tank bottoms to minimize corrosion.
2. Air-inlet screens must be clear of dirt, rust or frost as it is possible to rupture a tank by pumping oil into or out of it if the vents are frozen or otherwise clogged.
3. All valves, manual or automatic, for normal operation or emergency protection should be opened and closed several times to be sure that they are in operating condition.
4. If diesel fuel-oil storage tanks are wire-grounded, the grounds should be thoroughly checked.

Report on Assignment 8

Methods of Controlling Spillage of Fuel Oil at Diesel Fueling and Unloading Stations

V. C. Barth (chairman, subcommittee), W. F. Arksey, R. A. Bardwell, M. R. Bost, T. W. Brown, V. R. Copp, C. E. Fisher, H. E. Graham, A. W. Johnson, H. L. McMullin, G. F. Metzdorf, C. F. Muelder, E. T. Myers, John Norman, N. B. Roberts, J. P. Rodger, E. R. Schlaf, T. A. Tennyson, Jr., C. B. Voitelle, J. E. Wiggins, Jr.

The report of your committee this year deals with the use of automatic shut-off fueling devices manufactured by various companies for controlling the spillage of fuel oil at diesel fueling stations. The equipment is briefly described and the advantages and disadvantages of the various types are discussed.

A. THE PROBLEM

Eliminating diesel fuel-oil waste is vital to the economy of railroad operation. The fueling station has long been known as a major point of waste. A conservative estimate is that from one-half to two percent of all fuel oil used is lost from spillage or overflow. Average loss per filling is said to approximate 2 gal. Some fueling stations report as much as 450 gal of fuel oil in their waste sump each week.

B. GENERAL ADVANTAGES OF AUTOMATIC SHUT-OFF SYSTEMS

The committee, in making a study of the various designs, has observed that there are certain general advantages and disadvantages inherent in the use of automatic shut-off facilities. The advantages are that they—

1. Eliminate fuel-oil loss during fill up as much as 2 percent by volume, saving approximately $73 per locomotive per year.
2. Reduce labor cost. One man can fuel several locomotives simultaneously, thereby releasing labor for other duties.
3. Produce intangible savings, such as:
   a. Providing safer working conditions reducing injuries due to falls and slipping.
   b. Reducing fire hazard.
   c. Eliminating the need of clean-up programs.
   d. Reducing stream, harbor, and sewer pollution.

C. GENERAL DISADVANTAGES OF AUTOMATIC SHUT-OFF SYSTEMS

Unfortunately, the installation and use of automatic fueling systems has some disadvantages—

1. The initial investment is higher. This does not take into consideration rapid amortization of these devices.
2. Automatic devices have more functional parts and may require more maintenance.
3. Standardization and interchangeability of fueling fittings are limited.
4. Automatic refueling devices, in most instances, are in a state of design modification as changes are dictated by more extensive use.

D. FUNDAMENTAL REQUIREMENTS OF A SYSTEM FOR SATISFACTORY SERVICE

1. The units should be light in weight, and their construction should be consistent with good design and ruggedness for ease of handling and durability.

2. In the event of malfunction of an automatic device, a manual over-ride should be provided as an integral part of the nozzle, both for fueling and shut-off purposes.

3. During the transition period, automatic equipment should be reasonably compatible with existing fueling facilities.

4. Automatic devices (one-size nozzle) should accommodate the required rate of flow and a wide range in pressures, such as 25 to 400 gal per min and 15 to 90 psi.

5. The device should be slow in closing to minimize fuel pressure surge to avoid bursting of fuel hoses and "hammer" in pipelines in order to minimize consequential damage to meters and pumping equipment.

6. A screen should be placed directly ahead of the automatic fueling device to protect the nozzle against malfunction due to the presence of rubber particles and other foreign material in the fuel stream.

7. Automatic fueling devices should be guaranteed by a warranty for a reasonable period of time against defects or other unforeseen problems directly attributed to the automatic-nozzle-system design.

8. Automatic fueling devices should be reasonably compatible to permit interchangeability.

E. PRINCIPLE OF AUTOMATIC SHUT-OFFS

Alert to the problem of fuel spillage and waste, a number of manufacturers have developed automatic fueling units with special nozzles and fueling couplings designed to stop this waste. Automatic shut-off devices are located either in the nozzle, in the fill-up line, or on the locomotive coupling unit. The shut-offs are actuated by either liquid or air.

These devices prevent loss from two major causes: overflow from the locomotive vent pipe caused by overfilling the tank, and spillage from the fueling nozzle itself. In addition, some include a spring-loaded valve in the locomotive filler pipe to prevent spillage on curves should the dust cap be left off.

F. TERMINOLOGY

Before a brief description of the individual automatic refueling systems is given it is well to standardize the terminology of the various components. All of the systems have *fueling nozzles*. They all have *sensing devices* which must be located in the fuel tank itself or in the fill-up pipe. Some sensing devices are merely hollow tubes which operate on the Venturi principle, i.e., cutting off the fuel flow when the air flow stops. Others are small floats which shut off a pilot flow of liquid when the liquid level in the tank rises sufficiently high to raise the float. The sensing devices actuate the *power units* which shut off the flow of fuel. The power units are usually an integral part of the nozzles themselves, although they may be located on the end of the fuel fill-up pipes in the tank on each locomotive.

G. FIVE CURRENTLY AVAILABLE AUTOMATIC SHUT-OFFS

Five manufacturers are producing automatic fueling devices worthy of consideration at this time. There are, in addition, other manufacturers developing automatic fueling nozzles.

1. Type A Refueling System—Liquid-Flow Principle

This system (see Fig. 1) consists of three basic components: (a) Fuel nozzle. (b) Pilot valve, which is the sensing device mounted inside the fuel tank and is actuated

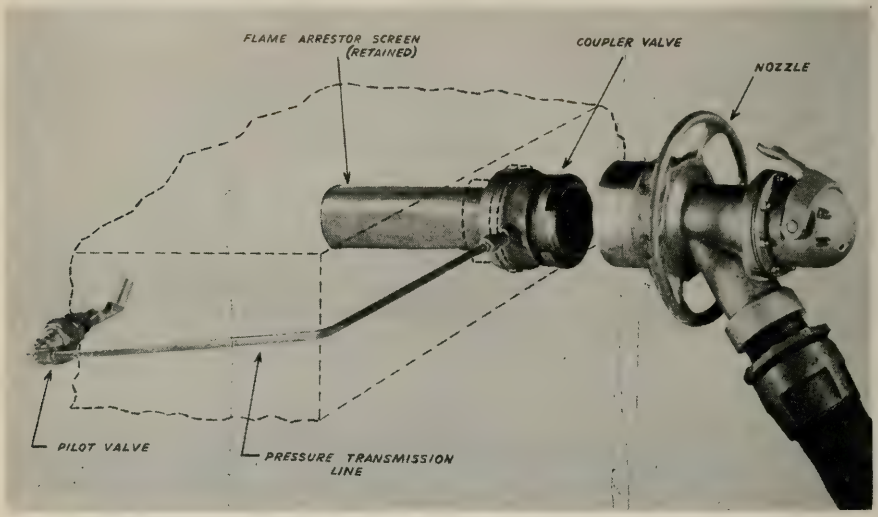

FLAME ARRESTOR SCREEN
(RETAINED)
COUPLER VALVE
NOZZLE
PILOT VALVE
PRESSURE TRANSMISSION
LINE

Fig. 1

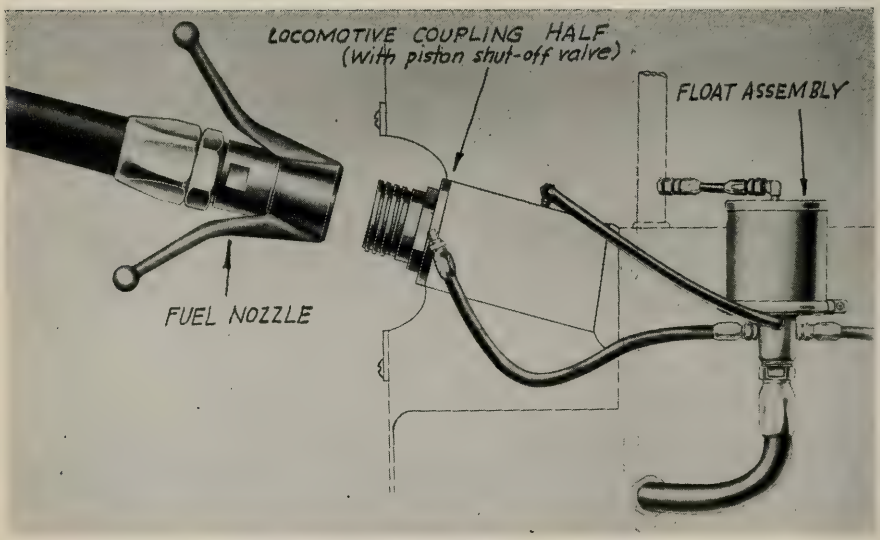

LOCOMOTIVE COUPLING HALF
(With piston shut-off valve)
FLOAT ASSEMBLY
FUEL NOZZLE

Fig. 2

by the fuel-oil level in the tank. This device is installed by drilling a hole in the tank at the desired level. (c) A coupler or shut-off valve. This is attached to the fill-up pipe on the locomotive fuel tank. The fueling nozzle attaches directly to this. The coupler or shut-off valve is the power unit which provides the force required to close the nozzle. The nozzle is furnished in one size only, regardless of the fuel flow requirements at any given point.

2. Type B Refueling System—Liquid-Flow Principle

This system (see Fig. 2) consists of three basic components: (a) Fuel nozzle. (b) A float assembly mounted externally on the fuel tank. To install, three drilled holes are necessary—in the fuel tank, the fill-up pipe, and the vent pipe. Tubing is run from these locations to the float assembly. Connection of the air vent line, the fuel float line, return line, and pressure line are required for proper functioning of the float assembly. The float assembly, pressure line, and return line form the sensing device which is actuated by the fuel-oil level in the tank. (c) A "locomotive coupling half" which is the power unit that shuts off the flow of fuel. This is attached to the fill-up on the fuel tank, and the nozzle attaches directly to this unit.

3. Type C Refueling System—Venturi Principle

This system (see Fig. 3) consists of two basic components: (a) Fuel nozzle. This contains the power unit as an integral part. The power unit provides the force necessary to close the nozzle. (b) The "adapter assembly" which is the sensing device and is in-

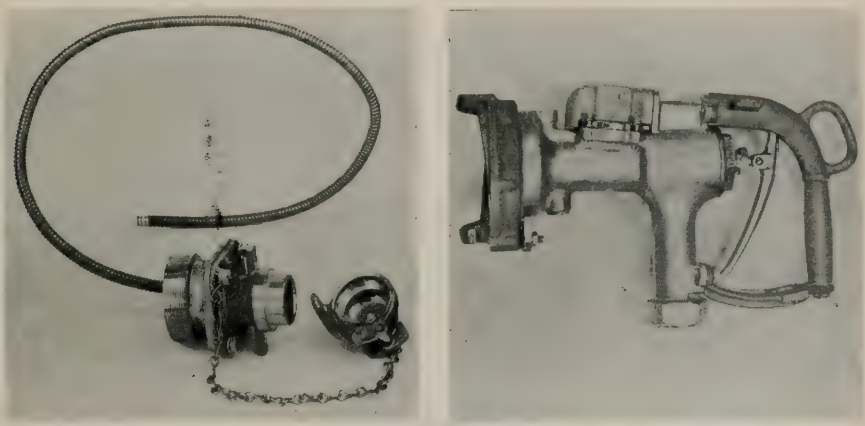


Fig. 3

stalled in the end of the fill-up pipe. It makes use of a quieting and sensing tube which extends down into the fuel tank. The Venturi principle is used in this sensing device, shutting off the air flow to the power unit. This nozzle is furnished in two sizes to cover the range of fueling rate required.

4. Type D Refueling System—Venturi Principle

This system (see Fig. 4) consists of two basic components: (a) Fuel nozzle. The fuel nozzle contains the power unit as an integral part which provides the force necessary to close the nozzle and shut off the fuel flow. (b) The sensing line, which is at-

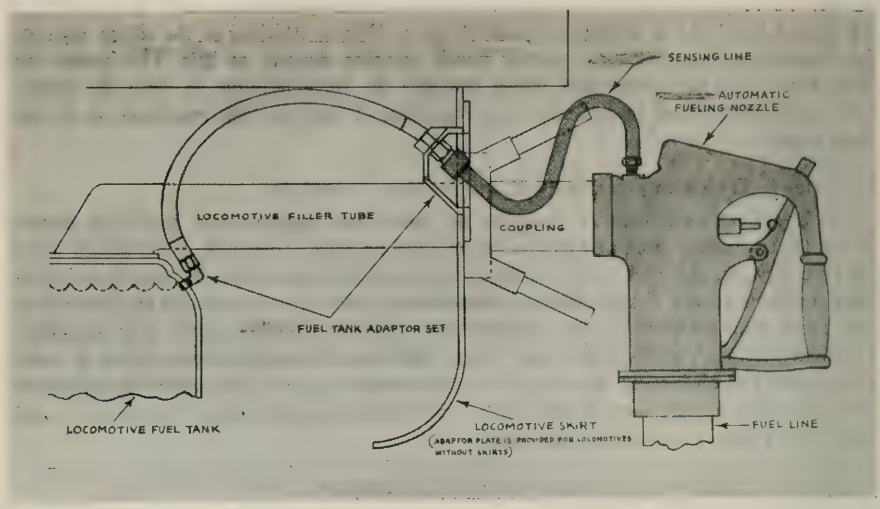

SENSING LINE
AUTOMATIC FUELING NOZZLE
LOCOMOTIVE FILLER TUBE
COUPLING
FUEL TANK ADAPTOR SET
LOCOMOTIVE FUEL TANK
LOCOMOTIVE SKIRT
(ADAPTOR PLATE IS PROVIDED FOR LOCOMOTIVES WITHOUT SKIRTS)
FUEL LINE

Fig. 4

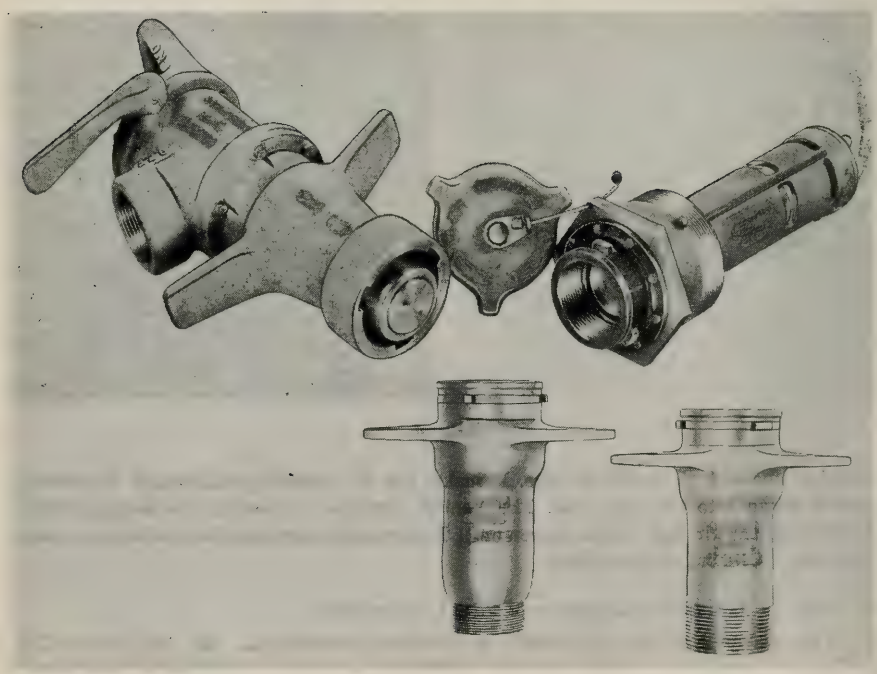


Fig. 5

tached to this nozzle and enters the side of the fuel tank at the desired fuel level location. This sensing device makes use of the Venturi principle—a shutting off of the air flow.

5. Type E Refueling System—Liquid-Flow Principle

This system (see Fig. 5) consists of two basic components: (a) Fuel nozzle closed by the power unit, the automatic shut-off valve located in the fill-up pipe. (b) The automatic shut-off valve which is inserted into the fill-up pipe on the tank. It contains a sensing device which is actuated by fluid pressure and contains its own power unit which simultaneously closes a valve stopping the fuel-oil flow into the tank and closes the fuel nozzle which stops the oil flow through the nozzle.

H. CONCLUSIONS

With respect to automatic fueling systems, it is generally agreed by the committee that the devices now available are in the proving stage. Although most devices have been used extensively, none is fully satisfactory because the manufacturers have disregarded standardization and interchangeability of the equipment. Little effort has been exerted in that direction cooperatively by the various manufacturers. This problem is something that the railroads, collectively, should impress upon the manufacturers.

COMPARISON CHART

	Type A	*Type B*	*Type C*	*Type D*	*Type E*
Flow rate (gpm—approx.)	20–400	10–300	20– 85 65–300	Not specified	Not specified
Compatibility with existing equipment during change-over period, without adapters	50%	No	No	100%	No
Manual over-ride on nozzle	Yes	No	Yes	Yes	Yes
Gradual shut-off nozzle, surge proof	Yes	Yes	Yes	No	Yes
Installation time, dual filler, hours	1	2–3	½	1–2	½
Drilled holes necessary for single-filler installation	1	3	0	1	0
Eliminates spillage from fuel tank*	Yes	Yes	No	No	Yes
Fills tank full automatically**	Yes	Yes	Yes	Yes	Yes
Requires secondary nozzle connection	No	No	No	Yes	No
Exterior sensing connection	Yes	Yes	No	Yes	No
Rugged design	Yes	Yes	Yes	Yes	Yes
Estimated amortization per year (based on 2 gal. loss per one fueling per day)	36.6%	52.1%	58.0%	116.2%	13.6%

*On negotiating curves or unlevel track if dust cap is inadvertently left off.
**If properly installed.

Report on Assignment 11

Methods of Heating Fuel Oil to Permit Winter-Time Use of High-Pour-Point "Economy" Grade Fuel Oil

C. E. DeGeer (chairman, subcommittee), V. C. Barth, D. E. Drake, H. M. Hoffmeister, J. J. Laudig, John Norman, N. B. Roberts, C. B. Voitelle.

The report of your committee this year is a consolidation of information developed during the past two years into a statement of recommended procedure, and is submitted as information.

A. GENERAL

The increased use of, and desire to use, "economy" type fuel oils having high pour and cloud points, has introduced the problem of having to heat these oils for wintertime use, especially such of those fuels that cannot be made usable through the use of chemical depresents.

B. METHODS OF HEATING

The heating of the fuel oils can be done through any means of inducing heat into the storage tanks, pipelines, filters, etc. The method of heating depends on the economy of the facilities available. Regardless of the type of heat selected, it is imperative to use moderate heat to prevent coking of the fuel oil onto the heating surfaces.

Keeping the fuel oil warm throughout the entire fueling facility is as important as initially heating the oil in the storage tank, for the wax in the fuel oil will tend to drop out in the cold portions of the facility. To accomplish this, the pipelines, filters, and dispensing equipment can be fully housed in warm buildings, they can be traced with steam, hot water, or electric heating lines, or a combination of these, plus the use of a circulating system to keep the warm fuel oil moving through them. Experience has shown that all of the facilities must be heated to handle "economy" fuels.

For economical heating, all facilities should be insulated with a moisture-proof type of insulation covered with 0.025-in reflective aluminum sheeting. Insulation of a foamglass or expanded-plastic type, which are nearly moisture proof, are recommended.

C. CONTROLS

Controlling the heat electrically is preferred, as it lends itself to very close control, especially if steam heat is used. As before mentioned, too high a heat will cause coking on the heating surfaces. To reduce the size of the heating media, an outdoor sensing thermostat can be used to start the heating process before the oil in the facilities becomes too cold. If mechanically controlled equipment is desired, such equipment should use control valves having close operating ranges.

D. ESTIMATED HEATING LOADS

The heating load required for storage-tank heating is based on:

1. Local mean temperature.
2. The temperature recovery time desired when cold oil is added to the storage tank. (This can be reduced somewhat by using a floating suction to the service pump).
3. The amount of insulation on the tank.
4. The amount of cold oil added daily to the tank.

The heating load for the balance of the fueling facility will depend on:

1. Local mean temperature.
2. Depth and length of oil line.
3. Type and size of fueling columns used.
4. Amount of heat in pump and filter houses.

As an example, the heat load required for ½-deg F temperature recovery per hour in an above-ground storage tank would be; $1.3^{-5} \times$ the number of gallons of oil $\times$ the

temperature differential desired in degrees F. The factor 1.3^{-6} is based on using 2 in of 0.25 K factor insulation covered with a reflective aluminum cover.

Due to variations in consumption, storage capacity, winter ambient temperature, and the loading procedures, a separate heating system for each fueling facility will have to be designed.

A test facility showed that very little heat is required to maintain warm oil in an insulated storage tank, once the oil had been warmed up. The bulk of the heating load is used to recover the desired temperature when cold oil is added to the storage tank and to keep the oil warm in the uninsulated portions of the fueling facility.

E. CONCLUSION

The cost of installing and operating the test facility described in the Proceedings, Vol. 59, pages 427 and 428, and Vol. 60, page 288, are as follows: To equip the 25,000-gal 11- by 25-ft tank was $4000. The cost of power to handle 608,400 gal of fuel oil over a 5-month period amounted to $440.03 (at 3.2 cents per kwh). This amounts to about 75 cents per 1000 gal, which shows that even at the high rate of 3.2 cents per kwh it is feasible to heat oil with electricity at a location where the mean temperature was about 10 deg F, during the test period.

It should also be kept in mind that a shift to dual fueling of diesels, using residual fuel and vapor-phase cooling, will make it mandatory to have heaters in the fuel-oil facilities; thus the heating of fuel oil is not only a means to an end at the present time, but will be a necessary preliminary step toward the use of residual fueling.

Report on Assignment 12

Plastic Pipe and Its Uses on Railroads

I. C. Brown (chairman, subcommittee), R. C. Archambeault, P. J. Calza, J. J. Dwyer, H. E. Graham, J. J. Laudig, G. F. Metzdorf, C. F. Muelder, J. P. Rodger, H. M. Schudlich, E. M. Walters, J. E. Wiggins, Jr.

Your committee submits the following final report as information.

Railroads require dependable, economical service from their extensive piping systems under all weather conditions. Generally, metallic pipe will best meet these requirements. While plastic pipe is not expected to replace metal pipe, it does have areas of service in which it can show advantages over metal pipe.

In recent years plastic pipe has found wide acceptance in industry, and many applications have been made on railroads. Successful installations of plastic pipe have been made for drinking water, deionized water, jet-pump lines, corrosive chemicals, vents, drains, sewers and septic-tank laterals.

Various types of plastic pipe have been developed. These are listed below according to their composition.

1. Polyethylene.
2. "C.A.B." (Cellulose-acetate-butyrate).
3. "A.B.S." (Acrylonitrile-butadiene-styrene).
4. "P.V.C." (Polyvinyl chloride).
5. Saran. (Vinylidene chloride).
6. Polyester glass.
7. Epoxy glass.

Table 1.

Material	Flexible or rigid	Available sizes, inches	Standard lengths, feet	Joining methods (fittings)	Allowable Operating Pressure for 2-inch pipe: PSI at 73 F.	Max. recommended opr. temp., F.	PSI at max. opr. temp.
Polyethylene, type I and II	Flexible	1/2 - 6	(a)	Clamping. Thermal welding.	50	120	24
Polyethylene, type III	Flexible	1/2 - 8	(b)	Clamping. Thermal welding.	75	150	30
C.A.B.	Flexible to rigid	1/2 - 8	20	Solvent welding.	95	140	50
A.B.S., type I	Rigid	1/2 - 12	20	Threading. Solvent welding.	75	170	40
A.B.S., type II	Rigid	1/2 - 12	20	Threading. Solvent welding.	100	180	25
P.V.C., type I	Rigid	1/4 - 12	20	Threading. Solvent welding. Thermal welding.	175	150	97
P.V.C., type II	Rigid	1/4 - 12	20	Threading. Solvent welding.	155	140	25
Saran	Rigid	1/2 - 6	10	Threading. Thermal Welding.	125	150	50
Polyester glass	Rigid	1 - 12	20	Threading.	500	200	500
Epoxy glass	Rigid	2 - 8	20	Threading.	700	300	350

For the same material, types differ in properties such as density, rigidity, and impact strength.

(a) Sizes under 4 inches in coils up to 400 feet. Sizes 4 inches and larger in straight cut lengths.

(b) Sizes under 3 inches in coils up to 400 feet. Sizes 3 inches and larger in straight cut lengths.

Table 2.

CHEMICAL RESISTANCE PLASTICS AND METALS [illegible] TEMPERATURE.

	Polyethylene	C.A.B.	A.B.S.	P.V.C.	Saran	Polyester Glass	Epoxy Glass	Carbon Steel	Copper	Aluminum
Potable water	Excel.	Poor	Excel.	Excel.	Good	Excel.	Excel.	Excel.	Excel.	Excel.
Distilled water	Excel.	Poor	Excel.	Excel.	Good	Excel.	Excel.	Poor	Excel.	Excel.
10% H_2SO_4	Excel.	Good	Excel.	Excel.	Excel.	Excel.	Excel.	Poor	Fair	Fair
50% H_2SO_4	Excel.	Poor	Excel.	Excel.	Excel.	Good	Excel.	Poor	Fair	Poor
10% NaOH	Excel.	Fair	Excel.	Good	Fair	Fair	Excel.	Excel.	Fair	Poor
50% NaOH	Excel.	Poor	Excel.	Excel.	Fair	Poor	Good	Excel.	Fair	Poor
$CuSO_4$	Excel.	Excel.	Excel.	Excel.	Excel.	Excel.	Excel.	Poor	Poor	Poor
Gasoline	Poor	Excel.	Excel.	Excel.	Excel.	Excel.	Excel.	Excel.	Excel.	Excel.
Benzene	Poor	Poor	[illegible]	Poor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Good	[illegible]	Excel.	Excel.	Excel.	Excel.

Plastic pipe can be classed into two basic groups: (a) thermoplastic, which can be softened and reshaped repeatedly by applied heat; and (b) thermosetting, which will set or harden into permanent shape after a single heating and cannot be appreciably changed by additional heating (types 6 and 7 above).

Some properties of plastic pipe are listed in Tables 1 and 2.

The advantages of plastic pipe are: Lower first cost then metallic pipe for similar service; light weight; resistance to acids, alkalies and corrosive soil conditions; low electric and heat conductivity; low friction flow loss; ease of installation and repair (some types); availability of long lengths; and the need for fewer fittings in flexible types.

The disadvantages are: Relatively low strength; pressure and temperature limitations; high expansion and contraction properties, requiring special installation to control creeping and breaking; poor resistance to weather (some types); and low impact strength.

Their low physical strength necessitates careful preparation of trenches to secure smooth, level surfaces. Lines of considerable length should be snaked 1 ft per 100 ft to permit expansion. The backfill around and for 6 in above the pipe should be rock-free to prevent damage to the pipe. Exposed pipe must be supported.

The lower cost plastics used in pipe form are generally not resistant to heat or petroleum products. Clamps for flexible plastic pipe fittings should be of stainless steel throughout, including screw and nut.

Pipe made of reclaimed plastic should not be used. For potable water the plastic must be of a non-toxic type, free from water-soluble plasticizers, and should be approved by local health authorities and the National Sanitation Foundation Testing Laboratory, Inc., Ann Arbor, Mich.

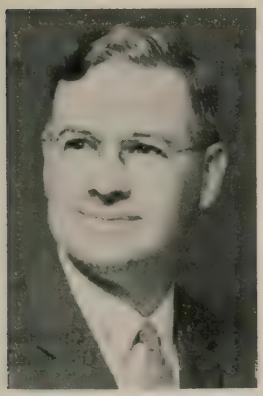
Each type and group of plastic pipe has distinctive physical and chemical characteristics. Selection should be made on recommendation of a reputable manufacturer.

Within its pressure and temperature limitations, plastic pipe of a type suitable for the material to be handled is a useful product for many railroad services.

REFERENCES

1. Flexible Polyethylene Plastic Pipe (Commercial Standards CS 197–59)—U. S. Government Printing Office.
2. Seal of Approval Listing of Plastic Materials, Pipe and Fittings for Potable Water Supplies—National Sanitation Foundation Testing Laboratory, Ann Arbor, Mich.
3. How and When to Use Plastic Pipe—Chemical Engineering, March 23, 1959.
4. Plastic Pipe—Materials and Methods, August, 1956.

Report of Committee 25—Waterways and Harbors



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Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   The material in the current Manual is of such character that revision, as of the end of 1959, is not indicated.

2. Current policies, practices and developments dealing with navigation projects, collaborating with AAR Committee on Waterway Projects.

   There have been no specific changes during the current year on the practices or policies of the Corps of Engineers in the handling of waterway projects. The committee's work on this assignment will be expanded during the coming year. It will collate and edit material from various sources for reprinting in the Bulletin for the information of the Association members.

3. Bibliography relating to benefits and costs of inland waterway projects involving navigation.

   Progress report, presented as information ..... page 308

4. Economic analysis of a completed waterway project.

   The committee has recommended that this subject be dropped, as it believes that available reports do not present the facts.

6. Planning, construction and maintenance of rail-water transfer facilities.

   This subject is being developed, particularly in the direction of bulk-handling facilities by conveyor and pipeline, and consideration of development of offshore mooring facilities.

7. Relative merits and economics of construction materials used in waterfront facilities.

   Progress report, presented as information ..... page 310

Supplemental paper entitled "Greenheart *(Nectandra Rodioei)*—Its Outstanding Merits, Properties, and Economics in Waterfront Facilites" ..... page 311

THE COMMITTEE ON WATERWAYS AND HARBORS,
J. F. PIPER, *Chairman.*

AREA Bulletin 553, November 1959.

Report on Assignment 3

Bibliography Relating to Benefits and Costs of Inland Waterway Projects Involving Navigation

M. A. Michel, (chairman, subcommittee), G. W. Becker, C. M. Bowman, A. F. Crowder, B. M. Dornblatt, N. E. Ekrem, R. B. Midkiff, J. G. Miller, W. J. O'Connell, M. S. Patterson, R. S. Rowe, C. M. Segraves.

Your committee submits the following report of progress, which presents annotations of one reference previously reported and four additional references with annotations.

1955

1. Commission on Organization of the Executive Branch of the Government—Task Force Report on Water Resources and Power—June 1955, set of three volumes, Government Printing Office, Washington, D.C. This reference was previously reported (see AREA Proceedings, Vol. 59, 1958, page 500). The new annotations are as follows:

In Vol. 1, pages 104–110, the Task Force outlines, in brief, the "Principles to be applied in determining economic justification of water resources and power projects and programs." Regarding benefits and costs relating to navigation, the following is quoted: "Navigation benefits of a waterway included should not exceed the savings in transportation cost made possible by the waterway improvement. Benefits of port development included should not exceed sound value of the services rendered by the improvement. Where reasonable estimates can be made of adverse effects on alternate means of transportation or on other communities, *these should be deducted as detriments, i.e., treated as negative benefits*" (emphasis added). The "Principles" also treat the "Benefit—Cost Ratio as a Measure of Economic Justification", in a comprehensive manner.

Vol. II, Appendix "N", is a brief but excellent, treatise on "The Lake Erie–Ohio River Canal Project", pointing out the importance of an ICC investigation and report on that project dated October 3, 1939, (No. 235 ICC), wherein the Commission concluded, in part, that the railroads which had "ample line and terminal capacity to handle any and all prospective traffic", could ill afford to suffer a "gross revenue loss of $35 million or more", annually ($100 million in 1959).

Vol. III (pages 1321–1393) contains an outstanding report by the Hoover Commission task force administrator, Chas. D. Curran, entitled "Evaluation of Federal Navigation Projects", which briefly but comprehensively covers salient economic facts relating benefits and costs on the following:

- The Missouri Navigation Project
- The Ohio Navigation Project
- The Warrior–Tombigbee Project
- The Proposed Tennessee–Tombigbee Waterway
- The Calumet–Sag Project
- The Delaware River Project—Philadelphia to Trenton
- The Sacramento Ship Canal
- The Upper Mississippi River
- The Arkansas River and Tributaries
- The Tennessee River

1957

2. Cecil B. Haver and Edward F. Renshaw—"The Future of the Illinois Waterway." An analysis of the interim survey report on duplicate locks for the Illinois Waterway by the United States Corps of Engineers.

Authors are associated with the Department of Economics, School of Business, University of Chicago, Chicago 37.

1958

3. Report to the Inter-Agency Committee on Water Resources—"Proposed Practices for Economic Analysis of River Basin Projects" prepared by the Sub-Committee on Evaluation Standards, May 1958. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C. Annotation on cover page is as follows:

"The Inter-Agency Committee on Water Resources has authorized the publication of this revised report in the belief that this material will be a valuable aid in the further consideration by the participating agencies and the interested public of the complex problems involved in evaluation of water resources projects. Publication of the revised report, however, and its adoption as a basis for consideration do not imply either that the proposed practices and recommendations of the report are thereby adopted for application by the participating agencies or that they represent Administration policy. Comments of the participating agencies are included in the appendix."

In Chapter IV—Measurement of Benefits and Costs, under the caption Consequential Damages, is the following recommendation: "Uncompensated adverse effects are costs of a project and should be treated in the same manner as other costs are treated for purposes of economic analysis". This seems to be reaching the same vein of thought as that derived by the Second Hoover Commission Task Force Committee regarding proper economic measurement of adverse benefits as related to navigation projects.

1958

4. John V. Krutilla and Otto Eckstein—"Multiple-Purpose River Development" (Studies in Applied Economic Analysis). Published for Resources for the Future, by Johns Hopkins Press, Baltimore, Md. Although this 277-page volume deals rather sparsely with inland waterways, it contains considerable material relating to Benefit–Cost Analysis, Benefit–Cost Ratio and effects of variable interest rates (federal, local and private) relative to financial justification of projects.

1959

5. Edward A. Ackerman and George I. G. Lof—"Technology in American Water Development." Published for Resources for the Future, Inc., by Johns Hopkins Press, Baltimore, Md.

This book, of 710 pages, was compiled to bring the technical horizon into better focus for businessmen, social scientists, administrators and lawyers interested in water development and management. Inland waterways navigation is studied from the views of water demand, water use, legislation dealing with it, and its management.

On page 584 the authors point out that large operational economies in navigation transportation have not as yet been realized, due to the absence of vital interbasin connections between centers of origin and destination of heavy traffic in the country. Typical examples are footnoted, including Lake Erie–Ohio River Canal, the Delaware–Hudson Canal, a deepened Lake Ontario–Hudson River Canal, the Tennessee–Tombigbee interconnection, and others.

Report on Assignment 7

Relative Merits and Economics of Construction Materials Used in Waterfront Facilities

Shu-tien Li (chairman, subcommittee), C. M. Bowman, L. W. Haydon, J. E. Inman, R. B. Midkiff, E. M. Skelton, F. R. Spofford, J. J. Tibbits.

Your committee submits as information the following report of progress.

1. Criteria of Relative Merits of Construction Materials Used in Waterfront Facilities on the Basis of Inspection, Tests, and Service Performance Records—These criteria were published in Bulletin 539, November 1957, reported at 1958 Convention, and may be found in the Proceedings, Vol. 59, 1958. They have been under continued study, and will be edited and submitted for adoption as recommended practice in the latter part of 1960. Comments on these criteria from the entire membership are invited.

2. Criteria of Comparative Economics on the Basis of Annual or Capitalized Cost Methods—These criteria were also published in Bulletin 539, November 1957, reported at 1958 Convention, and may be found in the Proceedings, Vol. 59, 1958. They have been likewise under continued study, and will also be edited and submitted for adoption as recommended practice in the latter part of 1960. Comments on these criteria from the entire membership are invited.

Both of the above criteria were originally authored by H. R. Peterson, chief engineer, Northern Pacific Railway.

3. Annotated Bibliography on Relative Merits and Economics of Construction Materials Used in Waterfront Facilities—A comprehensive annotated bibliography on this subject has been planned by your committee, and a modest request for funds to carry out the study has been made to the Board of Direction. The bibliography will be of value to all railroads concerned with the planning, design, construction, maintenance, and operation of waterfront facilities. This task will be undertaken as soon as the research funds requested therefor have been granted.

4. Greenheart *(Nectandra Rodioei),* Its Outstanding Merits, Properties, and Economics in Waterfront Facilities—Comprehensive research on this subject has been undertaken by Dr. Shu-tien Li, chairman of the subcommittee. The appended paper on the subject constitutes the first complete unit and is submitted herewith for information. It covers: A. Introduction, B. Scientific Name of Genuine Greenheart, C. Non-Genuine Greenheart, D. Outstanding Merits, E. Principal Waterfront Applications, F. Comparative Physical and Mechanical Properties, G. Comparative Allowable Unit Stresses, H. Geographical Service Records of Greenheart in Open Piling, I. Comparative Economics, J. Supply and Availability of "Demerara" Greenheart, K. Other Important Topics, L. Selected Bibliography.

"Demerara" is the name of the geographical locality in which genuine greenheart trees and hence their wood are produced. It is not a trade name, but a geographical designation, just as "Southern" is when used with Southern yellow pine. "Demerara greenheart" is simply an abridged way to represent the genuine greenheart of Demerara, British Guiana, South America. *Nectandra Rodioei* is its complete scientific name most commonly used by wood technologists in the United States.

A further report on greenheart forthcoming in the ensuing year will include:

1. Source and production of genuine greenheart;
2. Case histories and specific service performance records of greenheart;
3. Design criteria and examples for greenheart piling, decking, and fendering; and
4. Specifications for greenheart construction.

Greenheart *(Nectandra Rodioei)*—Its Outstanding Merits, Properties, and Economics in Waterfront Facilities

By Shu-tien Li

Chairman, Subcommittee 7 of Committee 25—Waterways and Harbors

A. INTRODUCTION

Genuine greenheart, whose generally accepted scientific name is *Nectandra Rodioei,* grows only in Demerara, British Guiana, situated on the northeast coast of South America. All authorities agree that this is the unique source of supply of genuine greenheart, the latest being Technical Memorandum No. 66, December 1955[(22)]* of Beach Erosion Board, Office of the Chief of Engineers, Corps of Engineers, U. S. Army. It is thus identified as Demerara greenheart.

This timber has been rated as the strongest, toughest, stiffest, and most lasting of any used for heavy construction today. For example, Sir William Matthews, K.C.M.G., chairman of the Special Committee on The Deterioration of Structures in Sea Water of The Institution of Civil Engineers of Great Britain, said in Engineering Review (London) for May 15, 1920: "Reports from widely different localities are practically unanimous in dividing timber into greenheart and others."

It was through Bancroft's "History of the Guianas" that the valuable properties of greenheart (the wood with the natural preservative from core to bark) first became known to timber merchants in England in 1769. Since that time greenheart has acquired a world-wide reputation for strength, durability, and resistance to marine borers and fungi.

B. SCIENTIFIC NAME OF GENUINE GREENHEART

"Greenheart" is the common name of a tree and, hence, of the wood that comes from it. Specifically, it is the name of a single well known species that can strictly be applied only to Demerara greenheart. The English almost 220 years ago gave it the descriptive name, greenheart, because of its greenish cast when split open.

The tree was first scientifically described as a species of *Nectandra.* Its generally accepted botanical name is *Nectandra Rodioei* assigned by Schomburgk in 1844. Later, in 1889, Mez reclassified and transferred it to *Ocotea,* and called it *Ocotea Rodiei.* Though taxonomists now agree it belongs to the genus *Ocotea,* they disagree as to which species was transferred and as to its spelling.

Samuel J. Record, professor of forest products and editor of Tropical Woods, Yale University, showed[(28)] in 1938 the confusion existing in literature on the subject by giving the following examples:

"In the first volume of Index Kewensis the name *Nectandra Rodioei* Hook. is given preference over *Nectandra Rodiei* Schomb., but the change in generic status is recorded in the first supplement as *Ocotea Rodiei* Mez (= *N. Rodiei* Schomb.).

"The name in general use in the British Guiana Forestry Department and the Forest Products Research Laboratory at Princes Risborough, England, is *Ocotea Rodioei* Mez.

"The editor of the Kew Bulletin presumably approves *Ocotea Rodioei* (Schomb.) Mez (e.g., 1936, p. 529), but Holland (Overseas Plant Products, 1937, p. 68) uses *Ocotea (Nectandra) Rodiaei.*

"Usage in three well known English books on woods is as follows: Boulger (Wood, p. 176), *Nectandra Rodioei* Schomb.; Stone (Timbers of Commerce, p. 176), *Nectandra Rodioei* Hook. (syn. *N. Rodier* Schomb.); Howard (Timbers of the World), *Nectandra Rodioei* Hook.

* Numbers in parenthesis refer to references in the bibliography at the end of this report.

"Pittier (Plantas Usuales de Venezuela, p. 398) says that the name for British Guiana Greenheart is *Ocotea Rodiei* (Hook.) Mez.

"Among Netherlands writers, Pfeiffer (De boutsoorten van Suriname 1:174 uses *Nectandra Rodioei* Hook. f. (syn. *Ocotea Rodiei* Mez, *Nectandra Rodier* Schk. en *N. Rodioei* Schomb.), while more recently Kostermans (in Pulle's Flora of Suriname 2:258) gives *Ocotea Rodiaei* (Rob. Schomb.) Mez (syn. *Nectandra Rodiaei* Rob. Schomb.)."

Subsequently, most writers quote both *Ocotea Rodioei* (Schomb.) Mez and its equal *Nectandra Rodioei* Schomb., as examplified in 1944 by W. D. Brush[38], wood technologist, Division of Forest Products, U. S. Forest Service. Brush also regards *Ocotea* and *Nectandra* as very closely related genuses instead of equal. Publications of British Guiana Timbers, Ltd., and Millars' Timber & Trading Co. Ltd., London, however, use *Nectandra Rodiaei* (Schomb.) and *Ocotea Rodiaei* (Mez). The latter name is used in Kent's Mechanical Engineers' Handbook, 1950. In Technical Memorandum No. 66 (December 1955) of Beach Erosion Board, Office of the Chief of Engineers, Corps of Engineers, and in recent publications of Greenheart (Demerara) Inc., *Nectandra Rodeoei* appears to be preferred.

C. NON-GENUINE GREENHEART

Demerara greenheart *(Nectandra Rodioei)* is not to be confused with other woods called greenheart. This common name has been indiscriminately applied to a considerable number of other woods, some of which have even been substituted occasionally for the genuine greenheart.

The name "greenheart" has attached itself to the tree variously known to the natives as "bebeeru" (the true greenheart), "bibiru", "supeira", etc. This came about because to casual observation the woods when split all showed a greenish cast. As loggers found other tropical woods that were also close-grained with a greenish cast, they assumed them to be the same as *Nectandra Rodioei* Schomburgk.

A great variety of woods has thus been regarded and accepted by inadequately informed producers and users. Even so reliable an authoritative work as Webster's International Dictionary describes greenheart as any of several tropical American trees furnishing somewhat greenish, usually hard, valuable wood; and also the wood; and identifies under the word greenheart not only (a) "bebeeru" *(Nectandra Rodioei),* but also (b) "Colubrina Ferruginosa", (c) "Zizyphus Chloroxylon", and (d) "bethabara." The latter three are quite different from the genuine greenheart.

The various non-genuine greenhearts were first described in about 1918 by C. D. Mell[9], beginning on page 173 of his manuscript on "Greenheart" deposited in the New York Public Library, and again in May 1944 by W. D. Brush[38] on "Greenheart" in Foreign Woods of the U. S. Forest Service. From these authoritative sources, the following data on non-genuine greenheart are excerpted. Mell enumerated 15 non-genuine greenhearts. After rearranging into alphabetical order, they are:

African greenheart—Essago—(A species of *Piptadenia*)
African greenheart—Ogwega—(*Dialium Guieense*)
African greenheart—Okan—(A species of *Piptadenia*)
Amapala greenheart (*Tecoma Araliacea* D.C.)
Amapala greenheart (*Tecoma Chrysantha* D.C.)
Aspalate greenheart (*Aspalathus Ebenus* Linn)
Bastard greenheart (*Calyptranthes Chytraculia* Linn)
Jamaica greenheart (*Ziziphus Chloroxylon* Oliver)
Santo Domingo greenheart (botanically unidentified, probably a species of *Dipholis*)
Sloane's greenheart (*Sloanea Jamaicensis* Hook)

Surinam greenheart (*Bignonia Leucoxylon* Linn)
Waibaima greenheart (also an unidentified member of the *Nectandra* Family)
Walebone greenheart (botanically unidentified, related to *Nectandra Rodioei*)
West India greenheart (*Colubrina Ferruginosa* Brongn)
West India greenheart (*Colubrina Reclinata* Brongn)

To preserve the original significance put forth by Brush, he is quoted verbatim below:

"There are several other species of *Ocotea* and also of the very closely related genus *Nectandra* that have wood similar to greenheart in general appearance. They are occasionally cut and sold with greenheart but can usually be distinguished from the latter by their lighter weight. These woods, which are often known under the name 'silverballi', are said to be inferior to greenheart in durability. A closely related species, known locally as waibaima and thought to be of the genus *Licaria,* has hard and heavy wood like greenheart but can be distinguished from the latter by its reddish-brown color. There is said to be a limited supply of this timber along the Essequibo and Demerara Rivers.

"Greenheart has been confused also with a closely related wood known in Brazil as itauba *(Mezilaurus itauba),* said to be the most useful timber of the Amazon region, especially for naval construction. The color of the heartwood is a brownish yellow.

"Another wood that is sometimes confused with greenheart is the bethabara of commerce *(Tecoma leucoxylon)* widely known because of its use in the manufacture of fishing rods. The tree grows in Surinam, French Guiana, and in British Guiana, and is sometimes called 'Surinam greenheart.' It is the pau d'arco of Brazil. It grows to large size and logs squaring 24 inches and from 20 to 40 feet long are available. It is considered a suitable substitute for the real greenheart in places exposed to the action of the teredo. Bethabara has a yellow desposit in the pores of the wood which distinguishes it from greenheart. This yellow deposit turns red when ammonia is applied to it.

"Dahoma *(Piptadena africana),* known also as ekhimi, is a large tree of the West African coast, the wood of which is sometimes called 'African greenheart.' The heartwood is golden-brown in color. It is a very heavy wood, weighing 45 to 50 pounds per cubic foot in an air-dry condition. The timber has been brought into English markets as a substitute for greenheart. As it is inferior to the latter wood in marine construction work it is now usually exported in the form of lumber and used for flooring, construction timbers, and railway ties.

"Manbarklak *(Eschweilera corrugata),* a very hard and heavy Surinam wood, is said to be practically immune from teredo attack and as suitable as greenheart for marine construction work. The heartwood is olive brown or reddish brown in color and is said to weigh about 76 pounds per cubic foot in an air-dry condition. In 1900 a firm in Holland began to import logs of this wood, but it proved so difficult to obtain timber according to specifications and so expensive to get the heavy material out of the forest that the operator found it impossible to compete with greenheart.

"Angelique *(Dicorynia paraensis),* a large tree of the lower Amazon region and the Guianas, has hard and heavy wood (weighing about 50 pounds per cubic foot, air-dry), said to be highly resistant to insect and fungus attack and moderately so to marine borers. It is used for marine construction work in the countries where it grows and has been suggested as a substitute for greenheart, from which it may be distinguished by its lighter weight and full olive-brown color, often with reddish patches.

"Almendro *(Coumarouna panamensis),* an important tree of eastern Panama, has been used as a substitute for greenheart in the lock gates of the Panama Canal. Its life

in teredo-infested waters was found to be about four years. The wood is hard and heavy, and the heartwood is brown or yellowish-brown in color. Like the tonca bean *(Coumarouna odorata)* of northern South America which has similar wood, it is valuable for its fruit, from which is obtained a fragrant oil used as a base for perfume.

"Several comparatively unimportant trees of the West Indies are called greenheart, but they are of little importance commercially. One of these is the so-called cogwood *(Ceanothus chloroxylon = Zizyphus chloroxylon)* of Jamaica sometimes called 'Jamaica greenheart.' The tree does not usually attain a diameter of more than one foot. The heartwood is yellowish-green in color and the wood is hard and heavy. It was formerly much used for the frames of sugar and coffee mills and for the rollers and the cogs of wheels in the cane crushers, but it is now scarce. Another wood of Jamaica, known as ironwood and breakax *(Sloanea jamaicensis),* is sometimes called 'Sloane's greenheart.' The tree grows to a diameter of one or two feet and the wood is hard and heavy. Little of this timber enters the trade. Two species of *Colubrina (reclinata* and *ferruginosa)* occur in the West Indies where they are known as ironwood, snakewood, and 'West Indian greenheart.' The first named species is found also in southern Florida where it is commonly called naked wood and soldier wood."

With so many substitutes masquerading under the same name, or with a qualifying adjective so easily confused, it is not surprising that the qualities of genuine greenheart became garbled in many minds by observation of inferior qualities of non-genuine greenheart.

The Forest Products Laboratory at Madison, Wis., in issuing on April 26, 1938, a copy of "Greenheart: A Timber with Exceptional Qualities"[6], by A. K. Armstrong (1915), put in the following note facing page 11 containing Examples of Use in Lock Gates:

> "The greenheart used in the Panama Canal lock gates did not give good service and much of it was destroyed by marine borers. Apparently, greenheart has been overrated for this use, especially in tropical waters, and we are not able to recommend it highly for the purpose."

However, as previously quoted from Brush (1944), the greenheart used in the Panama Canal gates was not genuine greenheart *(Nectandra Rodioei)* produced in Demerara of British Guiana, but Almendro *(Coumarona panamensis),* a local tree of eastern Panama. It was used as a substitute for greenheart in the lock gates of the Panama Canal. It had a life of only about four years in the teredo-infested waters at the lock site.

It is thus of paramount importance for engineers to distinguish genuine greenheart from all varieties of non-genuine greenheart. Before comparative laboratory tests and long-period service performance records become available for all genuine and non-genuine varieties of greenheart, the surest way to obtain quality greenheart in quantities is to specify "Demerara Greenheart *(Nectandra Rodioei).*"

D. OUTSTANDING MERITS

Marine Borers

Greenheart is highly resistant to marine borers. C. E. Baldwin once stated in "The Dock and Harbor Authority" that greenheart owes its power of resistance to worm infection to its texture, to the presence of an alkaloid (soluble in alcohol) known as bebeerine, and to the resinous tyloses. A. K. Armstrong, engineer in forest products, U.S. Forest Products Laboratory at Madison, Wis., in his "Greenheart: A Timber with

Exceptional Qualities," wrote in 1915: "It contains heartwood . . . which is probably more resistant to the teredo and other marine wood borers than any of the hundreds of species of timber so far used as piling."

Decay

Greenheart has immunity to decay. According to Armstrong (1915), "It contains heartwood that is almost immune to decay . . ." Further, in "Foreign Woods" of May 1944, of U. S. Forest Service, W. D. Brush wrote that the heartwood is nearly immune to fungus and termite attack.

Strength

The relative strength for construction purposes, according to Hurst's Architectural Surveyors Handbook, is 23 for greenheart and 10 for oak, teak, and yellow pine. Tests made by the University of Michigan, Columbia University, and the Chesapeake & Ohio Railway bear out these relative values.

Durability

According to expert authorities, C. D. Mell and W. D. Brush, in U. S. Forest Service Circular No. 211 (1913), authentic records show that the best grades of greenheart surpass iron and steel when placed in water or in contact with the soil.

Stiffness

Armstrong (1915) stated: "Its strength as a post or beam and its stiffness are considerably higher than that of the strongest and stiffest (black locust) of the 130 North American woods so far tested at the Forest Products Laboratory." Specifically, greenheart is found to be 25 percent stiffer than black locust.

Abrasion

Greenheart is highly resistant to abrasion, which makes it particularly suitable for use in bulkheads, as fenders, as sheathing for protection against floating ice, and for flooring and decking. It has been found to outlast oak and yellow pine by more than three to one.

Fire Resistance

In over-all resistance to fire, greenheart is rated by Lloyds of London in the "very high" category, as compared to "medium" for white oak, and "low" for Douglas fir. This exceptionally high resistance is directly attributable to the density of greenheart, and its lack of volatile oils.

Natural Preservation

Greenheart possesses a natural preservative, bebeerine, an alkaloid insoluble in water, which permeates the wood and cannot leach out. Because this natural preservative is integral with the cell structure, greenheart may be sawn or bored in the field without having to apply preservative to the freshly cut surfaces, as is necessary in framing treated woods.

Workability

Despite exceptional strength, there is no difficulty in framing greenheart with the same power tools as are used for the oaks, yellow pine, and Douglas fir.

E. PRINCIPAL WATERFRONT APPLICATIONS

Greenheart was first used as the fenders on a dock in England over 150 years ago. It is now used in all continents in marine construction. In North America, it is used from Maine to Florida, from the Panama Canal to the St. Lawrence Seaway, and from New York to Hawaii.

The principal waterfront applications are listed below:

Jetties	Fender systems
Groins	Pile fenders
Piers	Pile clusters
Pile bulkheads	Dolphins
Bulkhead walling	Sheet piling
Wharf decking	Foundation and bearing piles
Platform decking	Grillages
Transit-shed flooring	Braces
Warehouse flooring	Stringers
Dock gates	Car-ferry slips
Canal lock gates	Ferry racks
Marine railway chain troughs	Ferry driveways
Open-top railroad docks	Launchways, or slipways

Other uses that may be associated with, but not necessarily limited to, waterfront facilities are: material-handling chutes, decking for scows, trestles, drawbridge head blocks, bridge decking, boardwalk decking, highway grade crossings, fire breaks, roof trusses, laminated beams with softwood cores, and poles, crossarms, and braces of transmission lines.

F. COMPARATIVE PHYSICAL AND MECHANICAL PROPERTIES

The physical properties of green and air-dried greenheart, European oak, Douglas fir, and longleaf pitch pine are summarized in Table 1. Mechanical properties with like moisture contents for the same botanical species are summarized in Table 2. These are based upon test results at the Forest Products Research Laboratory of England, at the Forest Products Laboratory of Canada, and at the Forest Products Laboratory of U. S. Forest Service.

Comparative strengths in the green state of greenheart, white oak, longleaf yellow pine, and Douglas fir, are summarized in Table 3, according to test results from the University of Michigan[28], Columbia University[16], and the Chesapeake & Ohio Railway[25].

The superiority of greenheart in both physical and mechanical properties is convincingly revealed by the comparative test values. Tables 1, 2, and 3 bear out the labels given to greenheart by A. K. Armstrong[5] in 1915 as "A timber with exceptional qualities," and in the Marine News[29] of 1939 as "the king of structural timbers."

TABLE 1

Physical Properties of Green and Air-Dried Greenheart, European Oak, Douglas Fir, and Longleaf Pitch Pine, According to Timber Mechanics Section, Forest Products Research Laboratory, England

Standard Name		Greenheart		European Oak		Douglas Fir *		Longleaf Pitch Pine **	
Botanical Species		Ocotea rodiaei (Nectandra rodiaei Schomb.)		Quercus robur (Q. petraea)		Pseudotsuga taxifolia (P. douglasii)		Pinus palustris etc.	
Seasoning		Green	Air-Dried	Green	Air-Dried	Green	Air-Dried	Green	Air-Dried
Moisture Content	%	42	12	90	12	33	12	75	12
Shrinkage in Drying from Green to 12% Mois. Con.	Rad. %	2.7		2.6			2.5		2.1
	Tang. %	3.7		7.5			4.0		3.3
Wt. per Cu. Ft. at 50% Mois. Con.	lb.	76		52		40		46	
At 12% Mois. Con.	lb.		62		43		37		38
Specific Gravity, Oven Dry Weight, Volume at Test		0.82	0.89	0.55	0.61	0.46	0.50	0.49	0.53

*Tests at the Forest Products Laboratory of Canada.

**Tests at the Forest Products Laboratory, Madison, Wisconsin.

"Unmarked", test at Forest Products Research Laboratory, Timber Mechanics Section, Princes Risborough, Bucks, England.

TABLE 2

Mechanical Properties of Green and Air-Dried Greenheart, European Oak, Douglas Fir, and Longleaf Pitch Pine, According to Timber Mechanics Section, Forest Products Research Laboratory, England

Standard Name		Greenheart		European Oak		Douglas Fir *		Longleaf Pitch Pine **	
Botanical Species		Ocotea rodiaei (Nectandra rodiaei Schomb)		Quercus robur (Q. petraea)		Pseudotsuga taxifolia (P. douglasii)		Pinus palustris etc.	
Seasoning		Green	Air-Dried	Green	Air-Dried	Green	Air-Dried	Green	Air-Dried
(1) Static Bending:									
Equiv. Fibre Stress at Max. Load	lb/sq in.	19,300	30,500 S	8,100	13,300	7,700	13,300	7,800	13,400
Modulus of Elasticity	1000 lb/sq in.	2,970	3,400 S	1,290	1,560	1,700	2,050	1,470	1,850
Total Work	In lb/cu in.	35.5	——	20.4	19.1	17.9	22.5	27.6	18.7
(2) Impact Bending: Max. Drop	in.	46	62	34	33	24	40	32	32
(3) Compression Parallel to Grain: Max. Crushing Strength	lb/sq in	10,500	14,940	3,850	7,210	3,790	7,700	3,740	7,530
(4) Hardness (Janka), Indenting Load:									
On Side Grain	lb.	2,110	2,650	1,050	1,230	570	730	490	750
On End Grain	lb.	2,160	——	1,120	1,460	610	940	460	810
(5) Shear in Radial and Tangential Planes of Failure: Shear Strength	lb/sq in	1,320	2,830	1,170	1,760	920	1,460	910	1,390
(6) Splitting Strength in Raidial or Tangential Cleavage:									
Radial	lb/in width	420	370	390	360	210	220	200	270
Tangential	lb/in width	580	600	470	500	210	260	200	270

* Tests at the Forest Products Laboratory of Canada.
**Tests at the Forest Products Laboratory, Madison, Wisconsin.
"S" indicates small-size test pieces.

TABLE 3

Comparative Strengths in the Green State of Greenheart, White Oak, Longleaf Yellow Pine, and Douglas Fir, According to Test Results from the University of Michigan, Columbia University, and the Chesapeake and Ohio Railway

Standard Name	Greenheart	White Oak	Longleaf Yellow Pine	Douglas Fir
Botanical Species	Nectandra Rodioei	Quercus Alba	Pinus Palustris	Psendotsuga Taxifolia
Moisture Content at Test*-%	41.4	68.0	63.0	42.0
Specific Gravity, Oven Dry	0.91	0.60	0.54	0.44
(1) Static Bending:				
Modulus of Elasticity (1,000 lb per sq in)	3,103	1,500	1,600	1,740
Modulus of Rupture (lb per sq in)	17,900	8,100	8,700	8,200
Fibre Stress at Proportional Limit (lb per sq in)	11,700	4,700	5,200	5,200
(2) Compression Parallel to Grain:				
Fibre Stress at Maximum Load (lb per sq in)	10,500	3,500	4,300	4,010
Fibre Stress at Proportional Limit (lb per sq in)	8,500	3,090	3,840	3,430
Modulus of Elasticity (1000 lb per sq in)	2,280	——	——	1,930
(3) Compression Perpendicular to Grain: Stress at Proportional Limit (lb per sq in)	2,150	850	590	530
(4) Shear Parallel to Grain: Maximum Shearing Strength (lb per sq in)	1,850	1,040	1,290	920
(5) Cleavage: Radial Plane (lb per sq in)	420	——	210	220
Tangential Plane (lb per sq in)	580	——	210	220

*For lower moisture content, the various strengths are greater.

G. COMPARATIVE ALLOWABLE UNIT STRESSES

Based upon the test results given in Table 3, from the tests made at the University of Michigan, Columbia University, and the Chesapeake & Ohio Railway, comparative allowable unit stresses for greenheart, white oak, longleaf yellow pine, and Douglas fir, are given in Table 4. These allowable unit stresses are in conformity with those now being used by the leading port authorities and railroads in the United States.

In comparison with other timbers used in marine construction and heavy structures, the allowable static flexural stress for greenheart is 2 times and the allowable compressive stress parallel to grain is 2½ times greater than longleaf yellow pine, the strongest among other timbers in these mechanical properties. Greenheart is 3 times greater in allowable compressive stress perpendicular to grain than white oak, and also 3 times greater in allowable shearing stress parallel to grain than longleaf yellow pine, these species being the strongest counterparts of greenheart in these properties.

TABLE 4

Comparative Allowable Unit Stresses in Lb. per Sq. In. for Greenheart, White Oak, Longleaf Yellow Pine, and Douglas Fir, Based on Test Results Given in Table C

Standard Name	Greenheart	White Oak	Longleaf Yellow Pine	Douglas Fir
Botanical Species	Nectandra Rodioei	Quercus Alba	Pinus Palustris	Pseudotsuga Taxifolia
Flexural Stress (static)	3,300	1,400	1,600	1,450
Compressive Stress (Parallel to Grain)	3,000	1,000	1,200	1,100
Compressive Stress* (Perpendicular to Grain)	1,500	500	380	390
Shearing Stress (Parallel to Grain)	400	120	135	95

*For continuously wet conditions, the working compressive stress perpendicular to grain should be taken at 70% of the values given.

H. GEOGRAPHICAL SERVICE RECORDS OF GREENHEART IN OPEN PILING

Service performance records of greenheart timber are given in Table 5, arranged by geographical locations. They were originally compiled in 1955 by R. A. Jachowski[62], of the Beach Erosion Board, Corps of Engineers. However, two items were deleted for Table 5. The majority of the information is for greenheart piling in open pile structures. The records can be used as an indication of service life for greenheart sheet piling, fendering, and waling under alternate wet-and-dry conditions.

Most of the records available for greenheart timber are for marine structures in Europe. Greenheart piling and fendering have been in use in the United States for a comparatively much shorter period than in Europe. An analysis of the service records indicates that in waters of lower temperatures greenheart has a much longer service life than in tropical waters.

When these service records of greenheart are compared with those of the temperate-climate timbers—oak, southern pine, and Douglas fir—it should be kept in mind that the latter timbers require preservative treatment, careful handling, and good construction practices to resist marine-borer attack and attain a reasonable useful life, while greenheart does not require any treatment or special handling in the field to maintain its resistance, since the timber contains a natural preservative extending from the bark to the core.

Except those marked "failed" or "damaged" when the records were compiled in 1955, most of the installations in Table 5 are still in service. Knowing that there are so many non-genuine greenhearts that have been used during the past as substitutes for the genuine Demerara greenheart, it is very likely that some of the shorter-period service records of greenheart may involve non-genuine greenhearts.

I. COMPARATIVE ECONOMICS

In first cost, greenheart is comparable to properly creosoted softwood. But it generally lasts much longer. Thus, by taking into account maintenance and renewal costs, greenheart usually proves to be more economical.

Writing in The Dock and Harbor Authority of May 1953, A. M. Robertson states: "- - - - - as it is now the same cost as properly creosoted softwood and is vastly superior, there is now no need to consider softwood when dealing with marine structures." This is so because within recent years the higher increase in the cost of creosoting and the less increase in the price of greenheart have leveled off the slight higher cost for greenheart during the past.

TABLE 5

Service Performance Records for Greenheart as of 1955

Geographical Location	Years of Service	Remarks of Condition
Australasia		
Australia		
Port Elizabeth (a)	12	Failed
(b)	8	Damaged
Asia		
India		
Bombay	15-20	Failed
Calcutta	10	Failed
Indonesia		
Java	5-10	Failed
Europe		
Belgium		
Ostend	16	Slight attack
Zeebrugge	6	Slight attack
England		
Blackmill Bay	11	Damaged
Holyhead	20	Damaged
Liverpool (a)	80	Good
(b)	61	Good
(c)	38	Good
Plymouth	30	Failed
Portree	25	Failed
Salem	4	Attacked
Southhampton	10	Attacked
Sunderland	35	Failed
Yarmouth	25	Damaged
France		
Dunkerque	24	Slight attack
Havre	13	Good

TABLE 5 (Continued)

Service Performance Records for Greenheart as of 1955

Geographical Location	Years of Service	Remarks of Condition
Europe (Continued)		
Holland		
Friesland	18	Slight attack
Gostmahorn	18	Slight attack
Groningen	11	Slight attack
Harlingen	9	Good
Vlessingen (a)	16	Good
(b)	10	Slight attack
Walsoorden (a)	29	Good
(b)	10-21	Slight attack
Ymiden	12	Good
Scotland		
Bell Rock	19	Slight attack
Mithill (a)	24	Failed
(b)	14	Attacked
(c)	11	Failed
Wich	2-4	Attacked
North America		
United States*		
Hampton Roads, Va.	10	Good
South America		
British Guiana		
Georgetown	20-25	Failed
West Indies		
Trinidad (Br. Is.)	10-15	Failed

*During the past two decades there has been a gradual increase in Greenheart applications in the United States by various port authorities and railroads in waterfront facilities. Their case histories and specific service records will be surveyed, compiled, and presented in a later report.

Also, due to higher structural strength, the required dimensions of structural members fabricated from greenheart may be much less than those required of woods, such as oak, southern pine, and Douglas fir, grown in the temperate climates.

Construction practices such as (1) elimination of bracing within the tidal zone to the maximum practical extent, (2) prohibiting the use of untreated timbers above the permanent wet line, (3) avoiding boring and cutting of piles and timbers after treat-

TABLE 6

Reductions in Size, Greenheart Vs. Other Woods

Structural Components	Size for Other Woods	Size for Greenheart
Floor	4"	2"
Ties	8" x 8"	4" x 8"
Stringers	8" x 16"	6" x 12"
Braces	4" x 8"	3" x 8"
Sheet Piling (a)	3"	2"
(b)	6"	4"
Pile Clusters	———	25% to 40% less
Pile Fenders	6 ft. C. to C.	10 ft. C. to C.
Pile Bulkheads	4 ft. C. to C.	6 ft. C. to C.
Bulkhead Waling	12" x 12"	6" x 12"

ment, (4) field treatment of cut surfaces where they are unavoidable, and (5) care of the timber after a protective treatment has been applied, are not required if greenheart is used.

Any true, ultimate economic comparison between the use of untreated greenheart and other treated, temperate-climate softwoods, should take into consideration the reduction in size possible in the case of greenheart and the much longer service life that can be expected from it. Plans and specifications for greenheart design should be especially prepared in order to reap its maximum potential value. The mere calling of an alternative greenheart bid on the same design is basically unwarranted.

Typical reductions in size that can be made through the use of greenheart versus other woods are indicated in Table 6 for common structural components.

Many specific comparative examples may be worked out by applying the principles of structural design and allowable unit stresses given in Table 4.

In marine and heavy construction for which greenheart is eminently fitted, the main items to be considered in comparing greenheart with other treated softwoods are:

1. Spacing of piles and timbers to carry the same design load;
2. Life expectancy of each material according to service performance records under comparable conditions:
3. First cost or over-all cost of original construction;
4. Annual maintenance cost; and
5. Cost of renewal.

But the true, ultimate economic comparison must be computed on the basis of either the capitalized-cost method or the annual-cost method. In the former, item 4 should be capitalized; whereas in the latter, items 3 and 5 should be converted into equivalent annual costs; in either case the prevailing compound interest rate has to be applied to the computation.

The most decisive original cost of construction may be best taken at that bid by the lowest bidder. As an example, take the fender system—State Port Facilities, Wilmington, N. C.: 1780 lin ft, abrasion piles 55 ft 6 in long, 11 ft 3 in centers for greenheart, 7 ft 6 in centers for treated pine; bids received May 9, 1950.

Lowest bidder:	Greenheart	$59,098.74
	Treated pine	53,770.72
	Difference	$ 5,328.02

This difference in first cost of less than 10 percent can be easily overbalanced by the increase in service life of much more than 10 percent in the case of greenheart versus treated pine.

As a further example, take the fender system—State Port Facilities, Savannah, Ga.: 2048 lin ft, abrasion piles 57 ft 6 in long, 11 ft 3 in centers for greenheart, 7 ft 6 in centers for treated pine; bids received December 14, 1950.

Lowest bidder:	Greenheart	$54,106.40
	Treated pine	54,106.40
	Difference	None

There is no doubt in this case that the greenheart construction is the more economical because of its longer life expectancy.

J. SUPPLY AND AVAILABILITY OF DEMERARA GREENHEART

When specifying greenheart piles and sawn lumber it is of prime importance for the engineer to bear in mind that the genuine greenheart *(Nectandra Rodioei* or *Ocotea Rodioei)* of exceptional quality and commercial quantity for marine and heavy construction is produced only in Demerara, British Guiana. Due to the fact that other tropical woods which botanically belong to different genuses and species but bear a superficial resemblance to the genuine greenheart have been used as substitutes according to Brush[38] (1944) of U. S. Forest Service, it is recommended that purchasing or construction specifications should call for the following:

1. All greenheart piles and timbers shall be of genuine Demerara greenheart *(Nectandra Rodioei,* or *Ocotea Rodioei).*
2. All shipments of greenheart piles and timbers shall be accompanied by a British Guiana Forestry Department inspection certificate attesting as to genuineness of species and grade.

In the United States, greenheart has been exempted[68] from the "Buy American Act", and therefore, U. S. Coast Guard Comptroller Manual, Par. 3F01068, authorizes the procurement of greenheart without regard to country of origin, except for certain restrictions.

Demerara greenheart piles and sawn lumber are supplied and distributed in the United States by quite a few independent companies, and hence to specify genuine Demerara greenheart does not lose the advantage of competitive bidding.

In Demerara, British Guiana, reserve timber stands are abundant and capable of producing high-quality genuine greenheart for many years to come. Piles and timbers of this species are readily available in sizes and lengths which would be quite difficult to obtain in other woods, with grading and manufacture equal to the finest found anywhere.

Stocks of greenheart piles and lumber are available in New York, Florida, and Louisiana, for situations which demand immediate availability. On the loading beaches in British Guiana, each producer maintains, in water storage, an inventory of several thousand piles at all times, which facilitates delivery on short notice.

As to shipping service from British Guiana to the United States, there are two regularly scheduled lines operating between Georgetown, British Guiana, and Atlanta and

Gulf ports. Additionally, there are two other lines which operate on a semi-scheduled basis. All major Gulf and Atlantic coast ports are serviced. Discharge at minor ports can be arranged whenever the tonnage is sufficient. As a rule, there is a ship available in British Guiana to call at U. S. ports at least once every two weeks.

Round Piles

Round greenheart piles are readily available in lengths up to 75 ft, and to 85 ft on an accumulative basis. All greenheart piles are graded in accordance with ASTM standards, with butt and tip sizes conforming to Class "A" or "B" stipulations, whichever is required.

Greenheart piles are characterized by a very small taper. Where certain local conditions require piles with larger butt or tip diameters than those listed as the minimum sizes according to ASTM specifications, the use of greenheart piles can best meet such special requirements on an individual basis.

For estimating purposes, the following price structure applies for greenheart piles, f.o.b. dock, port of entry, Gulf or Atlantic coast, as of the time of this writing (end of September 1959):

Lenghts of Greenheart Piles	*Cost of Lineal Foot*	*Lenghts of Greenheart Piles*	*Cost per Lineal Foot*
Feet		*Feet*	
20	$1.55	50	$2.00
25	1.60	55	2.10
30	1.65	60	2.20
35	1.70	65	2.30
40	1.80	70	2.40
45	1.90	75	2.50

Lengths of 80 ft and over are available upon special order. Because of the high strength possessed by greenheart, extremely long piles can be built up in the field by splicing.

Sawn Lumber

At the suppliers' modern bandsaw mills in British Guiana, there are produced sawn greenheart, from 1-in boards to 16- by 16-in timbers, in lengths ranging to 40 ft, and occasionally longer, depending on size. It is safe to say that sawn greenheart can be had in sizes and lengths that would be very difficult, if not virtually impossible, to obtain in oak or pine.

Sawn greenheart lumber and timbers are exported from British Guiana in one grade only, i.e. "Export Quality", which grade is of higher quality than the top hardwood grade called "Select Dimension." Furthermore, all sawn greenheart lumber and timbers are of 3300 *F* stress grade; regardless of whether it is a board or the largest timber.

To help gain an idea of the production of sawn greenheart lumber, it suffices to state that one of the producers' modern mills turns out over 10,000,000 board feet per year. All sawn greenheart may be had dressed to specifications, as well as chamfered, precision cut to exact lengths, beveled, tapered, or grooved for sheet piling.

For estimating purposes, the following price structure applies to sawn greenheart lumber and timbers, f.o.b. dock, port of entry, Gulf or Atlantic coast, as of the time of this writing (end of September 1959):

Size	*Lengths (Run of Lengths)*	*Price per M Ft BM*
Up to 4 in thick by 12 in wide	10 ft and longer	$275
Over 4 in to 10 in thick by 12 in wide	10 ft and longer	285
12 in by 12 in to 14 in by 14 in	10 ft and longer	300

Larger sizes may be had by special order.

For specified lengths, add $10 per M ft bm.

The above prices do not include dressing and working charges.

K. OTHER IMPORTANT TOPICS

Other important topics of technological and economic significance concerning the use of greenheart as a natural engineering material in marine piling, decking, and fendering should include:

1. Source and production of genuine greenheart;
2. Case histories and specific service performance records of greenheart applications;
3. Design criteria and examples for greenheart piling, decking, and fendering; and
4. Specifications for greenheart construction.

These topics will each require considerable treatment to bring out valuable reference material in recommended form, and will be presented in forthcoming reports.

L. SELECTED BIBLIOGRAPHY

For those interested in the further study of greenheart, a selected bibliography on the 20th century literature concerning greenheart has been compiled, beginning from 1901 up to the end of 1958. There are 70 entries in this bibliography, arranged chronologically as follows:

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Report of Committee 6—Buildings

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(E) Member Emeritus.
* Died April 14, 1959.

To The American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Report on roofing specifications, presented with the recommendation that it be adopted and included in the Manual, taking the place of corresponding existing documents ..... page 332
2. Specifications for railway buildings.
   A specification for concrete masonry walls has been written but submission has been deferred until next year so as to include recommended procedures for expansion, contraction and control joints being reported under Assignment 5.
3. Prefabricated metal buildings for railway use.
   The committee has drafted a preliminary report on this assignment, and is now preparing a specification as part of the report to be presented as information next year.
4. Wind loading for railway building structures.
   Committee has in process the analysis of the data and the preparation of a report covering field tests conducted by the AAR research staff on a struc-

tural frame floodlight tower on the Santa Fe Railway in Clovis, N. Mex. It is proposed that additional fields tests be made on a tall, pipe floodlight tower. These tests on towers in several parts of the country will be reported by the committee with recommendations when the data have been compiled and studied.

5. Expansion, contraction and control joints in concrete and masonry block buildings.
   Final report, submitted as information ..... page 363

6. Modernization of power plants and heating systems for railway buildings.
   In the first year of work on this assignment a questionnaire has been circulated and preliminary report prepared. After further study, a report will be submitted next year.

7. New structural systems for railway buildings.
   Progress report, submitted as information ..... page 380

8. Infra-red ray heating, collaborating with Electrical Section, AAR.
   The committee proposes to progress this assignment next year, and submit conclusions based on available data on electric heaters and on the committee's progress report made in 1959 covering gas heaters.

9. Architectural requirements of railway buildings for housing electronic data processing machines.
   Final report, submitted as information ..... page 387

10. Consolidations of buildings at railway terminals.
    Final report, submitted as information ..... page 390

THE COMMITTEE ON BUILDINGS,
S. G. URBAN, *Chairman.*

AREA Bulletin 553, November 1959.

Report on Assignment 1

Revision of Manual

C. S. Graves (chairman, subcommittee), C. M. Angel, S. M. Bielski, R. R. Cahal, C. E. Close, R. L. Fletcher, I. G. Forbes, W. C. Humphreys, W. C. Oest, J. B. Schaub, Loren Shedd, R. C. Turnbell, O. G. Wilbur.

During the past few years, your committee has completely reviewed the specifications for roofing contained in Part 10 of Chapter 6 and has found them inadequate and obsolete.

This year these specifications were rewritten, and your committee now presents the new specifications for adoption and publication in the Manual to take the place of the following existing documents:

Pages 6-10-1 to 6-10-5, incl.

ROOFINGS—GENERAL

Pages 6-10-6 and 6-10-7

CLAY ROOFING TILE

Pages 6-10-7 to 6-10-9, incl.
CONCRETE ROOFING TILE

Pages 6-10-10 and 6-10-11
SLATE ROOFING

Pages 6-10-12 and 6-10-13
BUILT-UP ROOFING

Pages 6-10-13 and 6-10-14
TYPE A-1—TARRED RAG FELT, PITCH AND GRAVEL (OR SLAG) OVER WOOD OR PRECAST UNITS

Pages 6-10-15 and 6-10-16
TYPE A-2—TARRED RAG FELT, PITCH AND GRAVEL (OR SLAG) OVER HOMOGENEOUS ROOFS CAST IN PLACE

Pages 6-10-16 and 6-10-17
TYPE A-3—TARRED RAG FELT, STEEP ROOFING PITCH AND SLAG, FOR USE OVER WOOD OR PRECAST CONCRETE OR GYPSUM UNITS

Pages 6-10-17 and 6-10-18
TYPE A-4—TARRED RAG FELT, STEEP ROOFING PITCH AND SLAG, FOR USE OVER HOMOGENEOUS ROOFS CAST IN PLACE

Pages 6-10-18 and 6-10-19
TYPE B-1—ASPHALT RAG FELT, ASPHALT AND GRAVEL (OR SLAG) OVER HOMOGENEOUS ROOFS CAST IN PLACE

Pages 6-10-19 and 6-10-20
TYPE B-2—ASPHALT RAG FELT, ASPHALT AND GRAVEL (OR SLAG OVER WOOD OR PRECAST UNITS

Page 6-10-21
TYPE C-1—(CLASS 1)—ASPHALT IMPREGNATED ASBESTOS FELT AND ASPHALT (SMOOTH SURFACE) OVER WOOD OR PRECAST UNITS

Page 6-10-22
TYPE C-1—(CLASS 2)—ASPHALT IMPREGNATED ASBESTOS FELT AND ASPHALT (SMOOTH SURFACE) OVER WOOD OR PRECAST UNITS

Page 6-10-23
TYPE C-1—(CLASS 3)—ASPHALT SATURATED RAG FELT, ASPHALT IMPREGNATED ASBESTOS FELT AND ASPHALT (SMOOTH SURFACE) OVER WOOD OR PRECAST UNITS

Pages 6-10-24 and 6-10-25
TYPE C-2—(CLASS 1)—ASPHALT IMPREGNATED ASBESTOS FELT AND ASPHALT (SMOOTH SURFACE) OVER HOMOGENEOUS ROOFS CAST IN PLACE

Pages 6-10-25 and 6-10-26

TYPE C-2—(CLASS 2)—ASPHALT IMPREGNATED ASBESTOS FELT AND ASPHALT (SMOOTH SURFACE) OVER HOMOGENEOUS ROOFS CAST IN PLACE

Pages 6-10-26 and 6-10-27

TYPE C-2—(CLASS 3)—ASPHALT SATURATED RAG FELT, ASPHALT IMPREGNATED ASBESTOS FELT AND ASPHALT (SMOOTH SURFACE) OVER HOMOGENEOUS UNITS CAST IN PLACE

Pages 6-10-27 and 6-10-28

TYPE D-1—ASPHALT RAG FELT AND ASPHALT (SMOOTH SURFACE) OVER WOOD OR PRECAST UNITS

Page 6-10-29

TYPE D-2—ASPHALT RAG FELT AND ASPHALT (SMOOTH SURFACE) OVER HOMOGENEOUS ROOFS CAST IN PLACE

Following are the rewritten specifications submitted for adoption and publication in the Manual.

ROOFINGS—GENERAL

1. General

When selecting a type of roofing material for a railway building, the following factors should be considered:

a. Initial cost
b. Cost of maintenance
c. Probable life
d. Fire-resistive value
e. Architectural appearance

The type of roofing material to be used is, in general, controlled by the structural design of the building, its location and for what purpose the building is to be used.

Due consideration should be given to the materials, effectiveness in protecting the structure from the elements, its insulating qualities and fire-resistive values.

2. Basic Materials

The basic roofing materials are as follows:

a. Metals
b. Slate, tile and asbestos
c. Felts and fabrics
d. Bitumens
e. Shingles—asphalt and wood
f. Plastics

a. *Metals*

Copper, for centuries, has been the material of ultimate quality. It has adorned monumental buildings and endured functionally for hundreds of years. Because of the

attractive soft-green patina which forms on copper in most locations, no other material will so enhance in beauty with age. Copper combines the quality of stateliness with charm, warmth and dignity and with unparalleled service life. It is non-rusting, vermin-proof, non-porous, non-flammable, and impervious to penetration by water, moisture and air. Because of its high initial cost, it is seldom used on the average railway building.

Zinc alloyed with copper and other metals to increase its strength and formability has the outstanding ability to resist atmospheric corrosion, and is especially suitable for marine installations. Its cost is considerably less than copper; however, due to difficulties in fabrication, its use is not generally recommended by the trade.

The use of aluminum has increased rapidly in recent years, both as a structural metal and as a roofing material. Aluminum alloys have been developed that can withstand heavy wind and snow loads. Aluminum makes an ideal material for roofing domestic, commercial or institutional buildings and offers a pleasing appearance and long life with little maintenance. It may be obtained in flat or corrugated sheets. Aluminum is non-flammable, non-rusting, non-porous and impervious to moisture and air. It reflects radiant heat, thereby reducing interior temperatures in the summer. Its lightweight permits a saving in the cost of the supporting structure, which is an important factor when making a comparison of costs of roofing materials. Furthermore, its cost is considerably less than copper.

Galvanized iron or steel sheet is another class of material in general use mainly in prefabricated metal buildings and minor buildings.

Steel sheets that have been galvanized and then coated with an asbestos felt impregnated with asphalt, are available both as roofing and siding materials.

Metallic shingles, galvanized or painted, are available. A solid roof deck is recommended where they are applied.

Electrolytic action may take place when dissimilar metals are used in contact with each other. This possibility must be investigated and proper steps taken to insulate them from each other.

b. *Slate, Tile and Asbestos*

Slate roofing material is generally used for ornamental purposes and requires a steep-pitched, heavy-framed supporting structure. Its use for railway structures is limited.

Clay tile is mainly used as a decorative material to carry out a certain style of architecture. Like slate, it requires a heavy supporting structure, and its use is limited for railway structures.

Asbestos shingles made of asbestos fibers and portland cement, make an excellent roofing material for some classes of buildings. They are available in a number of colors, sizes and shapes and must be applied over a layer of felt on solid sheathing. Due to their weight, a somewhat heavier roof structure is required. Their use is not recommended on roofs having a slope less than 4 in per ft.

Corrugated asbestos sheets made of asbestos fibers and portland cement, make an excellent roofing material for buildings having a minimum slope of 3 in or more per foot. It requires no special tools for application and can be installed as rapidly as any other corrugated material. It can be applied directly to purlins without sheathing by means of screws or bolts, and produces practically a permanent roof. It requires no protective painting or other maintenance expense and minimizes fire risks due to its composition. It is not affected by corrosion and is decay proof.

c. *Felts and Fabrics*

Felts are made of vegetable or animal fibers, usually rags or cotton, and asbestos fibers, saturated with a bitumen, asphalt or coal-tar pitch. Asbestos felts absorb less of the bitumen saturant than rag felts and act more as a protection to the layers of bitumen. They are more expensive than rag felts, but have some peculiar and valuable qualities. Asbestos fibers, being mineral, are not subject to decaying as is the case with vegetable fibers used in the rag felts.

The preservative and waterproofing characteristics of asphalt are due to certain oily constituents. In the manufacture of roofing materials it is desirable to construct the body of the sheet of a highly absorbent felt impregnated or saturated to the greatest possible extent with the type of oil-rich asphalt known as saturant, and then seal the saturant in with an application of a harder, more viscous coating asphalt which itself can be protected, if desired, by a covering of talc.

Ready-to-lay roofing, in general, consists of several plies of felt cemented together at the factory with asphalt into heavy, strong sheets. They may have a smooth surface or be coated with mineral granules. They may be obtained in flat sheets or in rolls. They are ordinarily packaged with galvanized nails, lap cement and butt-lap strips.

Ready-to-lay roofing may be made of asphalt-saturated rag or asbestos felts, with the rag-felt base being somewhat cheaper than the more enduring asbestos roofings.

Ready-to-lay roofings are more adapted to steep-pitched roofs and are cheaper than the built-up types. On flat slopes they are hard to lay watertight and are not recommended for application on slopes of less than 3 in per ft.

This type of roofing material is recommended for use on small roadside and shop buildings where the architectural treatment is not under consideration.

d. *Bitumens*

Asphalt: Asphalt has been used as a preservative, waterproofing and adhesive agent since the dawn of history. The Babylonians used it to waterproof their baths and as a paving material. The Egyptians used it in the preservation process on mummies. Throughout the Middle Ages asphalt was common in Europe. One of the largest natural deposits was discovered by Columbus on the Island of Trinidad during his third voyage in the year 1498. This deposit is now known as Lake Trinidad asphalt.

The asphalt used today in the manufacture of asphalt roofing materials is obtained mostly from the petroleum industry. It is the product of the fractional distillation of crude oil that occurs towards the end of the distillation process and is known to the trade as "asphalt flux." It is sometimes refined by the oil producer and sold to the roofing manufacturer in accordance with his specifications; however, many manufacturers purchase the flux and do their own refining.

Coal-Tar Pitch: Coal-tar pitch is obtained from the destructive distillation of bituminous coal. It is easily affected by heat and cold, is not acted upon at all by water, is easily worked and, if properly protected, is very stable. It should ordinarily be used as it comes from the still, straight run, of a consistency suitable to the climate and to proper application.

Water Gas-Tar: Water gas-tar pitch, a by-product of the manufacture of artificial gas, resembles coal car; however, it is inferior to coal tar for roofing purposes, and any materials made from it should only be accepted in the low-priced products. It has more value as a saturant of felts than as a coating.

e. *Asphalt Shingles*

Asphalt shingles similar in composition to ready-to-lay roofing with mineral-coated surfaces are made of high-grade rag felt saturated with asphalt and then given a further coat of harder asphalt, into which is imbedded colorful mineral granules.

The durable color of the surface granules eliminates the expense of periodic painting, and they also make the shingles highly fire retardant.

The various styles of asphalt shingles are available in a wide range of colors and blends which produce pleasing, varigated effects without too sharply contrasting hues and shades. Color harmony between the structure and the surrounding landscape can be readily made with the variety of colors. They are available in many weights and sizes.

A good grade of asphalt shingle has as long a life as built-up roofings and may be used on permanent buildings.

Wood Shingles: Wood shingles and wood shakes have been used on buildings for many years and have given excellent service; however, due to the fire-hazardous nature of the material, they are not recommended for railway buildings.

f. *Plastics*

Plastic panels are composed of tough, weather-resistant and light-stabilized resins reinforced with high-strength glass fibers. Such a panel is light in weight, shatter-proof, will not rot or mildew, resists surface erosion, resists flying objects for personnel protection, requires a minimum of framing for installation and requires no special tools.

Plastic panels can be used with corrugated or other types of formed roof without special curbs for skylights. They can also be used with special curbs as skylights on flat built-up roofs.

Plastic panels are fire-resistant and are made in several colors for use as siding as well as roofing.

3. Built-Up Roofs

Roofs composed of built-up layers of felt cemented together with asphalt or pitch and with or without a mineral surface are especially valuable for flat or slightly sloped surfaces. By using special kinds of asphalt they may be applied on roof surfaces having a slope as much as 6 in per ft. Such roofs are more difficult to apply and the results are less certain.

Built-up roofs may be divided into three main groups, depending upon the materials used, as follows:

a. *Asphalt and Asbestos Felts*

This type of roof does not require a mineral surface for the Underwriters' Class "A" rating.

When composed of proper grades and weights of felts, this type of roof may be expected to give excellent service for a long period of years; however, in certain climates it may be desirable to apply a coat of primer or asphalt to liven up the felts. Care should be taken to see that the roof deck is absolutely dry to prevent the possibility of vapor pockets forming under the roofing, producing bulges in the felts with possible cracking of the felts.

b. *Asphalt and Rag Felts*

This type of roof is built-up of alternate layers of asphalt-saturated rag felts and hot, liquid asphalt and may or may not be finished with gravel or slag. To obtain an Underwriters' Class "A" rating, this type of roofing must be mineral surfaced. The

asphalt should be carefully selected, and the use of inferior grades should be avoided because of their tendency to become brittle and crack. Great care is necessary in applying these roofs to see that each layer of felt is thoroughly imbedded in asphalt while it is still hot, as under ordinary conditions the asphalt will not soften enough to cement the sheets of felt together once it has cooled.

c. *Pitch and Rag Felts*

This type of roof is built-up of alternate layers of tar-saturated rag felts, cemented together with coal-tar pitch and coated with crushed stone, gravel or slag, bedded in a poured coating of pitch. Although brittle in cold weather, pitch softens under ordinary summer temperatures, and the layers gradually become thoroughly cemented together.

Roofs of this type must have a mineral surfacing to protect the pitch from the direct rays of the sun and keep it from running in warm weather. This type of roofing is limited to use on roof decks having slopes of not more than 2 in per ft.

Roofs of pitch and felts are recommended for use where the roof surface is to be flooded to relieve summer heat or for use as a spray pond, as pitch is not affected by water standing on it.

There are many modifications in the types of roofs, depending on the number of plies of felts, weights of felts, etc., which may be selected to serve a specific case. Costs of the roof covering also has a considerable bearing on what class of roofing material will be used.

Specifications for various classes of built-up roofs are also given in detail in Part 10, this Chapter.

4. Roof Flashing

The flashing is the most vulnerable part of any roof. The prevention of seepage or leaks at masonry walls of the modern building is a serious problem confronting every architect, engineer and builder.

All flashing materials should be furnished by the manufacturer of the roofing material and should be the best of their kind.

5. Protection

Where a built-up roof is subject to wear from traffic of any kind, it should be protected by thin, flat tiles placed over the top sheet of felt.

6. Workmanship

A careful inspection of the workmanship involved in applying any of the foregoing materials should be made, as the life and efficiency of the materials depend on careful application.

7. Guarantee

The practice of depending upon the guarantee or bond in selecting materials cannot be relied upon to secure proper results; however, the bond offered is an indication of its probable service life.

CLAY ROOFING TILE

1. Special Note

The General Conditions as given in Part 1, this Chapter, shall be considered to apply with equal force to this specification, and the contractor shall consult them in detail for instructions pertaining to his work.

2. Scope of Work

The contractor shall furnish all labor, materials, tools, scaffolding and equipment, unless otherwise noted, necessary for and reasonably incidental to the furnishing and application of all classes of clay roofing tile, including the necessary fittings, as shown on the drawings and as hereinafter specified.

3. Materials

All roofs as indicated on the drawings shall be covered with . . . pattern clay roofing tile complete with stock fittings as manufactured by . . . , of the pattern and color shown on the drawings.

Tile samples shall be submitted for approval.

Felt shall be 30-lb asphalt-saturated asbestos felt conforming to current ASTM Specifications, designation D 250.

Nails for fastening tiles shall be non-corrosive roofing nails 1½ or 1¾ in long, as required.

4. Condition of Roof Decks

The contractor shall examine all roof surfaces on which or against which his work is to be applied. He shall examine all areas to see that the surfaces are properly sloped to drains and in proper condition to receive his material.

The contractor shall see that all defects are corrected and that all grades are properly constructed before proceeding with his work, otherwise the contractor shall replace at his own expense all roofing which may have to be removed to correct defects or that is damaged thereby. Cants shall be installed in angles formed by the intersection of the roof deck and adjoining vertical surfaces.

Before applying any roofing the contractor shall remove all rubbish, the deck being made and maintained perfectly clean and free of loose or foreign materials and obstructions other than the tools and appliances of the roofer.

5. Application

Lay asphalt-saturated asbestos felt parallel to the eaves, lapping sheets 2½ in horizontally and 6 in vertically. Fasten felts with ¾-in galvanized nails on 6-in centers. Extend felt 6 in on vertical walls and 4 in over gutter and valley metal. Felt shall be doubled on low-pitched roofs (5 in per ft and under), rough surfaces, hips, valleys and ridges.

Tiles shall be fastened with non-corrosive nails and shall be well locked together, laid smoothly with no attempt to stretch the courses. The tiles shall be laid so that the vertical lines are parallel with each other and at right angles to the eaves.

Tiles shall be laid with head lap as specified by the manufacturer.

6. Sheet Metal Work

Flashings and other sheet metal work required in connection with the application of a clay-tile roof covering shall be furnished and installed in accordance with the specifications for Sheet Metal Work, Part 11, this Chapter.

7. Guarantee

The contractor as a condition to final payment shall furnish a written warranty countersigned and guaranteed by the general contractor that all roofing work shall be free from defects of materials and workmanship for a period of . . . years.

SLATE ROOFING

1. Special Note

The General Conditions as given in Part 1, this Chapter, shall be considered to apply with equal force to this specification, and the contractor shall consult them in detail for instructions pertaining to his work.

2. Scope of Work

The contractor shall furnish all labor, materials, tools, scaffolding and equipment, unless otherwise noted, necessary for and reasonably incidental to the furnishing and application of the slate roofing, together with all slate covering the vertical surfaces of dormers, as shown on the drawings and as hereinafter specified.

3. Materials

The slate shall be genuine ....., as furnished by the ....., of the following sizes and thickness: .....

All slate shall be hard, dense, sound rock, machine punched for two nails each.

Exposed corners shall be practically full. No broken corners on covered ends which sacrifice nailing straight or the laying of a watertight roof will be allowed.

Samples of slate shall be submitted for approval before ordering, and all slate shall conform with the approved samples.

Felt shall be 30-lb asphalt-saturated asbestos felt conforming to current ASTM Specifications, designation D 250.

Nails shall be large-head, slaters, hard-copper wire nails, 1¼ in long for slate 18 in or less and 1½ in long for slate 20 in or longer.

Nails for felt shall be large-head, galvanized roofing nails ¾ in long.

4. Condition of Roof Decks

The contractor shall examine all roof surfaces on which or against which his work is to be applied. He shall examine all areas to see that the surfaces are properly sloped to drains and in proper condition to receive his material.

The contractor shall see that all defects are corrected and that all grades are properly constructed before proceeding with his work, otherwise, the contractor shall replace at his own expense all roofing which may have to be removed to correct defects or that is damaged thereby. Cants shall be installed in angles formed by the intersection of the roof deck and adjoining vertical surfaces.

Before applying any roofing the contractor shall remove all rubbish, the deck being made and maintained perfectly clean and free of loose or foreign materials and obstructions other than tools and appliances of the roofer.

5. Application

Lay asphalt saturated asbestos felt parallel to the eaves, lapping sheets 2½ in horizontally and 6 in vertically. Fasten felt with ¾-in galvanized nails on 6-in centers. Extend felt 6 in on vertical surfaces and 4 in over gutter and valley metal. Felt shall be doubled on low-pitched roofs (5 in per ft and under), rough surfaces, hips, valleys and ridges.

The entire roof surfaces and other surfaces as indicated on the drawings shall be covered with slate, as herein specified, in a proper and water-tight manner.

The slate shall be laid in horizontal courses with a 3-in head lap, and each course shall break joints with the preceding one by at least 3 in. The slate shall project 2 in at the eaves and ½ to 1 in at the gable ends. Slates at the eaves or cornice line shall be doubled, using the same thickness of slate for undereaves as for the first exposed course, and shall be canted ¼ in by a wooden cant strip.

Each slate shall be fastened with two large-head copper nails, driven so that the next course will not ride on the nail head. Nails shall not be driven in so far as to produce a strain on the slate. Cover all exposed nail heads with plastic cement.

Slates overlapping sheet-metal work shall have the nails so placed as to avoid puncturing the sheet metal. Exposed nails shall be permissible only in top courses where unavoidable.

Slates at hips and ridges shall be laid to form "saddle" ridges. Nails of the combing slate shall pass through the joints of the slates below.

Valleys shall be laid to form "open" valleys.

Slate shall be carefully fitted to all wall flashings; small pieces of slates at vertical walls, valleys, eaves and hips will not be permitted.

6. Sheet Metal Work

Flashings and other sheet-metal work required in connection with the application of a slate roof covering, shall be furnished and installed in accordance with the specifications for Sheet Metal Work, Part 11, this Chapter.

7. Guarantee

Upon completion of the work the contractor shall furnish a written guarantee covering the maintenance of the slate roofing in a water-tight condition for a period of one year from the date of acceptance, replacing or repairing any broken slates or leaks as promptly as notified until the end of the guarantee period.

BUILT-UP ROOFING AND FLASHING—GENERAL INFORMATION

1. Special Note

The General Conditions as given in Part 1, this Chapter, shall be considered to apply with equal force to this specification, and the contractor shall consult them in detail for instructions pertaining to his work.

2. Scope of Work

The contractor shall furnish all labor, materials, tools, scaffolding and equipment, unless otherwise noted, necessary for and reasonably incidental to the furnishing and application of the built-up roofings as shown on the plans and as hereinafter specified.

3. Materials

Asphalt for built-up roofs shall conform to current ASTM Specifications, designation D 312.

Asphalt primer for use on concrete and gypsum roof decks shall conform to current ASTM Specifications, designation D 41.

Coal-tar pitch for roofs of slopes of 2 in per ft and under shall conform to current ASTM Specifications, designation D 450, while for roofs with inclines of 1 to 6 in per ft, it shall conform to designation D 654.

Creosote for priming concrete and gypsum roof decks shall conform to current ASTM Specifications, designation D 43.

Asphalt-saturated rag felts shall conform to current ASTM Specifications, designation D 226.

Asphalt-saturated asbestos felts shall conform to current ASTM Specifications, designation D 250.

Asphalt-saturated rag felt for combination asbestos–rag felt roofing shall conform to current ASTM Specifications, designation D 655.

Coal-tar-saturated rag felt shall conform to current ASTM Specifications, designation D 227.

4. Roof Deck Requirements

It is essential that all roof decks be inspected before work is started, for in a large measure, the success of a roof covering is dependent upon properly constructed roof decks.

Roof decks should always be graded to drain all water freely into gutters and downspouts. Drainage connections should be set to permit the free flow of water.

Cants shall be installed in the angles formed by the roof deck and adjoining vertical surfaces.

All rubbish shall be removed and the deck made and maintained perfectly clean and free of loose or foreign materials and obstructions other than the tools and appliances of the roofer.

New wood roof decks should be constructed of well seasoned boards, preferably with the moisture content of each board not in excess of 15 percent and preferably with matched joints. The boards shall be free of knot holes and shall be installed with tight joints to avoid serious cracks.

All conditions applying to new wood decks apply to old wood roof decks, and in addition, all loose nails shall be driven flush, additional nailing of old boards done where required, all decayed, splintered or weakened boards removed and replaced with new boards. Any large cracks or knot holes shall be covered with tin or sheet metal nailed in place.

Poured concrete or gypsum decks shall be smooth, firm, thoroughly set, dry, free from frost or the effects of freezing, properly graded and free from loose material. If the deck is rough, having sharp or abrupt ridges, projections, or marked depressions, the high spots must be removed or the low spots filled with portland cement or gypsum mortar thoroughly bonded to the deck.

Precast concrete slab decks shall be smooth and firm. If the surface formed is uneven, that is, one slab setting enough higher than another to cause a break in the roofing, this condition shall be corrected by leveling off such places with portland cement mortar or the slab reset, so that an even surface is obtained. All joints between slabs and all depressions shall be filled up with portland cement mortar.

Steel roof decks shall have at least ½ in of approved insulation applied to the deck before the application of built-up roofing felts.

The design of some steel deck units is such as to require the insulation to span appreciable openings; the thickness of the insulation to be used is predicated on the width of such unsupported areas, and the minimum thickness should be specified by the roofing supplier.

5. Vapor Barrier

A vapor barrier of specially compounded flexible fire-retardant material should be placed between the steel roof deck and the insulation, especially in buildings that are to be air conditioned or heated or have a high humidity factor.

6. Preparation of Materials

All materials shall be kept dry and clean. Rolls of felt, drums of asphalt, etc., shall be placed on end and the rolls of felt properly covered.

In cold weather, felts composed of several plies shall not be thrown or dropped, as the shock of impact may fracture the asphalt between, thus separating the plies.

Bitumen shall be broken up, placed in the kettles, melted and frequently stirred to prevent burning.

Precaution should be taken not to mix asphalt and pitch in the same kettle. The kettle used for either asphalt or pitch shall be burned and thoroughly cleaned out before being used for the other bitumens.

Pitch shall not be heated to exceed 400 deg F. If the white vapor coming from the kettle turns yellow, draw some of the fire and add cold pitch.

Asphalt shall not be heated to exceed 450 deg F. with a mean temperature of 425 deg at the bucket desirable. It is recommended that a suitable thermometer be kept in the kettle to check the temperatures.

7. Application

Leaky buckets must not be used. Bitumen or primer splashed on a porous surface can never be entirely removed.

Where a separation is required between a built-up roof and a wood deck, a layer of rosin-sized paper shall be applied to prevent adhesion to the deck and seepage of the bitumen through the joints of the deck.

Non-nailable decks shall be primed before applying built-up roofing. Steel decks which are not shop coated in manufacture, shall have a coat of primer before applying insulation. All masonry wall surfaces that are to be flashed shall receive a coat of primer.

In applying built-up roofing felts, it is important that they be laid so that the flow of water shall be over or parallel to—never against—the exposed edges of the felt.

On smooth-surface roofs where the slope is 3 in per ft or less, the felts may be laid either parallel with or at right angles to the eaves. Where the slope exceeds 3 in per ft, all felts shall be laid parallel to the slope.

Felts shall be applied as described in the following specifications, and in no place on the roof shall there be less than the number of plies of felts called for in the specifications.

The felts shall be rolled closely behind the mop so that at no time shall the mopping be more than 3 ft ahead of the roll. A sufficient quantity of bitumen shall be used so that it will flood ahead of the roll in an unbroken line, thus filling all depressions and allowing the felt to be firmly embedded. *The felts must be broomed in while the bitumen is still hot.* A stable type of broom or suitable squeegee must be used for this purpose.

An exception to the foregoing shall be made only when the specifications call for "spot mopping." In such instances the bitumen shall be applied in spots approximately 12 in in diameter, 24 in center to center longitudinally, in 3 rows per width of felt, staggered.

In applying felts to wood decks, the bitumen must not be allowed to contact the wood at any point. Failure to follow this precautionary measure will probably result in drippage through the joints, or tearing of the felts through movement of the boards to which the felts have adhered because of the spillage.

Felts composing built-up roofs shall be turned up 2 in on vertical surfaces which are to be flashed (unless sheet-metal flashing is to be used). These felts shall be cemented to the vertical surface.

8. Insulation

Approved roof-insulating materials must be firm and capable of withstanding traffic without crushing. It must be thoroughly dry before being applied. No more insulation shall be laid at one time than can be immediately protected by the laying of felt. Wet or damp insulation will be rejected as a base to receive built-up roofing felts.

Where buildings are heated or air conditioned or will contain abnormal humidity in temperatures under 45 deg F., a vapor seal between the deck and insulation is recommended.

9. Guarantee

The contractor shall furnish an unqualified guarantee with good and sufficient bond covering the maintenance of the entire roof and all flashing in a watertight condition for a specified period of years from the date of completion and acceptance of the entire roof.

10. Acceptance

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the engineer, and no part of the work will be considered as finally accepted until all of the work is completed and accepted.

TAR-SATURATED RAG FELT, COAL-TAR PITCH, GRAVEL OR SLAG SURFACE OVER WOOD DECK, PRECAST GYPSUM SLABS, PRECAST CONCRETE SLABS OR OTHER NAILABLE MATERIAL

A. 15-YEAR SERVICE LIFE

For application over roof surfaces having an incline from dead level to not exceeding 2 in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(for wood deck only) one layer of red rosin paper.
Felts	4 layers of 15-lb tar-saturated rag felt.
Bitumen	60 lb for mopping between felts;
	60- to 75-lb flood coat to receive aggregate.
Aggregate	400 lb of gravel, or
	300 lb of slag.
Accessories	Nails, tin disks, etc.

2. Application

The Specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin) lapping the sheets not less than 1 in and nailing as often as necessary.

Second: Over the entire surface lay two plies of 15-lb tar-saturated rag felt, lapping each sheet 19 in over the preceding one and turning up these felts not less than 4 in along all vertical surfaces. Nail as often as necessary to hold in place to secure until the remaining felt is laid.

Third: Coat the entire surface uniformly with coal-tar pitch at the rate of 30 lb per 100 sq ft of roof surface.

Fourth: Over the entire surface lay two plies of 15-lb tar-saturated rag felt, lapping each sheet 19 in over the preceding one, mopping with coal-tar pitch the full 19 in on each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of 30 lb of coal-tar pitch per 100 sq ft of roof surface.

The back edge of each sheet shall be nailed at intervals of 24 in at a distance not greater than 6 in from the back edge of the sheet. Such nailing as is necessary shall be done so that all nails are covered by not less than one ply of felt.

Fifth: Over the entire surface pour a uniform coating of coal-tar pitch, 60 to 75 lb per 100 sq ft of roof surface, into which, while hot, embed 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size, dry and free from dirt.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with the specifications for Sheet Metal Work, Part 11, this Chapter, and in addition, the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

B. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from dead level to not exceeding 2 in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(for wood deck only) one layer red rosin paper.
Felts	5 layers of 15-lb tar-saturated rag felt.
Bitumen	90 lb for mopping between felts;
	75-lb flood coat to receive aggregate.
Aggregate	400 lb of gravel, or
	300 lb of slag.
Accessories	Nails, tin disks.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper apply two layers of 15-lb tar-saturated rag felt. Beginning at the low point of the roof deck, apply a half-width sheet on top of which shall be nailed the second, full width, so that the lower edges of the 2 sheets are even with the edge of the roof. The remaining sheets shall each lap 19 in over the preceding sheet and shall be nailed sufficiently to hold in place.

Third: Over the two layers of felt thus applied, mop three layers of 15-lb tar-saturated rag felt to the roof. Start with a one-third-width sheet, on top of which shall be mopped a two-thirds-width sheet, on top of which shall be mopped a full width sheet, so that lower edge of the three sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 25 in over the preceding sheet, mopping the coal-tar pitch the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

The back edges of the sheets shall be nailed at intervals of 24 in at a distance not greater than 6 in from the back of the sheet. Such nailing as is necessary shall be done so that all nails are covered by not less than two plies of felt.

Fourth: Over the entire roof surface pour a uniform coating of 75 lb of coal-tar pitch per 100 sq ft of roof surface, into which, while hot, embed not less than 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size, dry and free from dirt.

3. Flashing

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with the specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

TAR-SATURATED RAG FELT, COAL-TAR PITCH, GRAVEL OR SLAG SURFACE OVER POURED CONCRETE, POURED GYPSUM, PRECAST CONCRETE SLABS OR OTHER NON-NAILABLE MATERIAL

A. 15-YEAR SERVICE LIFE

For application over roof surfaces having an incline from dead level to not exceeding 2 in per ft.

Note: On insulated steel roof decks, the manufacturer shall be consulted to obtain his recommendation as to thickness of insulation and its application to secure bond on the roofing material. Bond does not cover the insulation.

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Felts	Three layers of 15-lb tar-saturated rag felt.
Bitumen	90 lb for mopping between felts; 75-lb flood coat to receive aggregate.
Aggregate	400 lb of gravel, or 300 lb of slag.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roof deck is poured concrete or poured gypsum, coat the entire roof surface uniformly with coal-tar pitch at the rate of 30 lb per 100 sq ft of roof surface.

If the roof deck is constructed of precast concrete slabs, the coal-tar pitch shall be omitted for a width of 4 in on each side of all joints.

Second: Beginning at the low point of the roof deck, mop three layers of 15-lb tar-saturated rag felt to the deck. Start with a one-third-width sheet, on top of which shall be mopped a two-thirds-width sheet, on top of which shall be mopped a full-width sheet so that the lower edge of the three sheets are even with the edge of the roof.

The remaining sheets are all full width, lapped 25 in over the preceding sheets, mopped the full width of each sheet, with 30 lb of coal-tar pitch between each sheet, so that at no time shall felt touch felt.

At angles formed by the intersection of the roof deck and vertical surfaces, felts shall be applied over the cant strip and not less than 6 in high on the vertical surface, measured above the top of the cant strip.

Third: Coat the entire surface of the felts thus applied with a mopping of coal-tar pitch at the rate of 75 lb per 100 sq ft of roof surface, into which, while hot, embed not less than 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size and free from dirt.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with the specifications for Sheet Metal Work, Part 11, this Chapter, and in addition, the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

B. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from dead level to not exceeding 2 in per ft.

Note: On insulated steel roof decks, the manufacturer shall be consulted to obtain his recommendation as to thickness of insulation and its application to secure bond on the roofing material. Bond does not cover the insulation.

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Felts	4 layers of 15-lb tar-saturated rag felt.
Bitumen	110 to 120 lb, for mopping between felts; 75-lb flood coat to receive aggregate.
Aggregate	400 lb of gravel, or 300 lb of slag.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roof deck is poured concrete or poured gypsum, coat the entire roof surface uniformly with coal-tar pitch at the rate of 30 lb per 100 sq ft.

If the roof deck is constructed of precast concrete slabs, the coal-tar pitch shall be omitted for a width of 4 in on each side of all joints.

Second: Beginning at the low point of the roof deck, mop four layers of 15-lb tar-saturated rag felt to the deck. Start with a quarter-width sheet, on top of which shall be mopped a half-width sheet, on top of which shall be mopped a three-quarter-width sheet, on top of which shall be mopped a full-width sheet so that the lower edges of the four sheets are even with the edge of the roof.

The remaining sheets are full width, lapped 27½ in over the preceding sheets, mopped the full width of each sheet, with 30 lb of coal-tar pitch between each sheet, so that at no time shall felt touch felt.

At angles formed by the intersection of the roof deck and vertical surfaces, felts shall be applied over the cant strip and not less than 6 in high on the vertical surface, measured above the top of the cant strip.

Third: Coat the entire surface of the felts thus applied with a mopping of coal-tar pitch at the rate of 75 lb per 100 sq ft of roof surface, into which, while hot, embed not less than 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size and free from dirt.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with the specifications for Sheet Metal Work, Part 11, this Chapter, and in addition, the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Condition, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

ASPHALT-SATURATED RAG FELT, ASPHALT, GRAVEL OR SLAG SURFACE OVER WOOD DECK, PRECAST GYPSUM OR OTHER NAILABLE MATERIAL

A. 15-YEAR SERVICE LIFE

For application over roof surfaces having an incline from ½ in to 3 in per ft.

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Sheathing paper	(for wood deck only), one layer red rosin paper.
Felts	4 layers of 15-lb asphalt-saturated rag felt (perforated).
Bitumen	60 lb for mopping between felts; 70-lb flood coat to receive aggregate.
Aggregate	400 lb of gravel or 300 lb of slag.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper apply two layers of 15-lb asphalt-saturated rag felt. Beginning at the low point of the roof deck, apply a half-width sheet, on top of which shall be nailed the second, full width, so that the lower edges of the two sheets are even with the edge of the roof. The remaining sheets shall each lap 19 in over the preceding sheet and shall be nailed sufficiently to hold in place.

Third: Over the two layers of felt thus applied, mop two layers of 15-lb asphalt-saturated rag felt to the roof. Start with a one-half-width sheet, on top of which shall be mopped a full-width sheet, so that lower edge of the two sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 25 in over the preceding sheet, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt.

Moppings between sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

At angles formed by the intersection of the roof deck and vertical surfaces, felts shall be applied over the cant strip and not less than 6 in high on the vertical surface, measured above the top of the cant strip.

Where the incline of the roof deck is 2 in or more each ply of asphalt felt shall be nailed 1½ in from the upper edge, spacing the nails on 12-in centers. Such nailing as is necessary shall be done so that all nails are covered by not less than two plies of felt.

Fourth: Over the entire roof surface pour a uniform coating of not less than 70 lb of asphalt per 100 sq ft of roof surface, into which, while hot, embed not less than 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size, dry and free from dirt.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

B. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from ½ in to 3 in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(for wood deck only), one layer red rosin paper.
Felts	5 layers of 15-lb asphalt-saturated rag felt (perforated).
Bitumen	90 lb, for mopping between felts; 70-lb flood coat to receive aggregate.
Aggregate	400 lb of gravel, or 300 lb of slag.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper apply two layers of 15-lb asphalt-saturated rag felt. Beginning at the low point of the roof deck, apply a half-width sheet, on top of which shall be nailed the second, full width, so that the lower edges of the two sheets are even with the edge of the roof. The remaining sheets shall each lap 19 in over the preceding sheet and shall be nailed sufficiently to hold in place.

Third: Over the two layers of felt thus applied, mop three layers of 15-lb asphalt-saturated rag felt to the roof. Start with a one-third-width sheet, on top of which shall be mopped a two-thirds-width sheet, on top of which shall be mopped a full-width sheet, so that lower edge of the three sheets are even with the edge of the roof.

The remaining sheets, all full width, shall lap 25 in over the preceding sheet, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

At angles formed by the intersection of the roof deck and vertical surfaces, felts shall be applied over the cant strip and not less than 6 in high on the vertical surface, measured above the top of the cant strip.

Where the incline of the roof deck is 2 in or more, each ply of asphalt felt shall be nailed 1½ in from the upper edge, spacing the nails on 12-in centers. Such nailing as is necessary shall be done so that all nails are covered by not less than two plies of felts.

Fourth: Over the entire roof surface pour a uniform coating of not less than 70 lb of asphalt per 100 sq ft of roof surface, into which, while hot, embed not less than 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size, dry and free from dirt.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

ASPHALT-SATURATED RAG FELT, ASPHALT, GRAVEL OR SLAG SURFACE OVER POURED CONCRETE, POURED GYPSUM, PRECAST CONCRETE SLABS OR OTHER NON-NAILABLE MATERIAL

A. 15-YEAR SERVICE LIFE

For application over roof surfaces having an incline from ½ in to 3 in per ft.

Note: *On insulated steel roof decks, the manufacturer shall be consulted to obtain his recommendation as to thickness of insulation and its application to secure bond on the roofing material. Bond does not cover the insulation.*

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Concrete primer	1 gal.
	3 layers of 15-lb asphalt-saturated rag felt, perforated.
Bitumen	75 to 90 lb, for mopping between felts;
	60 to 70 lb flood coat to receive aggregate.
Aggregate	400 lb of gravel, or
	300 lb of slag.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roof deck is poured concrete or poured gypsum, coat the entire roof surface with concrete primer and allow it to dry thoroughly. Where the roof deck is precast concrete slabs, the primer shall be omitted for a width of 2 in on each side of all joints.

Second: Coat the entire roof surface with a mopping of hot asphalt at the rate of 30 lb per 100 sq ft and beginning at the low point of the roof deck, mop three layers of asphalt-saturated felt to the deck. Start with a one-third-width sheet, on top of which shall be mopped a two-thirds-width sheet, on which shall be mopped a full-width sheet so that the lower edges of the three sheets are even with the edge of the roof.

If the roof is precast concrete slabs, spot-mop the roof deck in a manner similar to the first step above instead of solid mopping.

The remaining sheets are full width, lapped 25 in over the preceding sheets and mopped the full width of each sheet, with 30 lb of asphalt between each sheet, so that at no time shall felt touch felt.

At angles formed by the intersection of the roof deck and vertical surfaces, felts shall be applied over the cant strip and not less than 6 in high on the vertical surface, measured above the top of the cant strip.

Third: Coat the entire surface of the felts thus applied with a mopping of asphalt at the rate of 60 to 70 lb per 100 sq ft of roof surface, into which, while hot, embed not less than 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size, and free from dirt.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition, the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

B. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from ½ to 3 in per ft.

Note: *On insulated steel roof decks, the manufacturer shall be consulted to obtain his recommendation as to thickness of insulation and its application to secure bond on the roofing material. Bond does not cover the insulation.*

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Concrete primer	1 gal.
Felts	4 layers of 15-lb asphalt-saturated rag felt, perforated.
Bitumen	110 to 120 lb for mopping between felts; 60 to 70-lb flood coat to receive aggregate.
Aggregate	400 lb of gravel, or 300 lb of slag.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roof deck is poured concrete or poured gypsum, coat the entire roof surface with concrete primer and allow it to dry thoroughly. Where the roof deck is precast concrete slags, the primer shall be omitted for a width of 2 in on each side of all joints.

Second: Coat the entire roof surface with a mopping of hot asphalt at the rate of 30 lb per 100 sq ft, and beginning at the low point of the roof deck mop four layers of 15-lb asphalt-saturated felt to the deck. Start with a quarter-width sheet, on top of which shall be mopped a half-width sheet, on top of which shall be mopped a three-quarter-width sheet, on top of which shall be mopped a full-width sheet, so that the lower edges of the four sheets are even with the edge of the roof.

The remaining sheets are full width, lapped 27½ in over the preceding sheets mopped the full width of each sheet with 30 lb of asphalt between each sheet, so that at no time shall felt touch felt.

At angles formed by the intersection of the roof deck and vertical surfaces, felts shall be applied over the cant strip and not less than 6 in high on the vertical surface, measured above the top of the cant strip.

Third: Coat the entire surface of the felts thus applied with a mopping of asphalt at the rate of 60 to 70 lb per 100 sq ft of roof surface, into which, while hot, embed not less than 400 lb of gravel or 300 lb of slag. The gravel or slag shall be ¼ to ⅝ in. in size and free from dirt.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition, the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

4. Gravel Stops

Edges and eaves of gravel- or slag-surfaced roofs must be finished with suitable metal gravel stops having flanges extending at least 4 in out onto the roof.

ASPHALT-SATURATED ASBESTOS FELTS AND ASPHALT, SMOOTH SURFACE, OVER WOOD DECK, PRECAST GYPSUM OR OTHER NAILABLE MATERIAL

A. 15-YEAR SERVICE LIFE

For application over roof surfaces having an incline from ½ in to 6 in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(for wood deck only) one layer red rosin paper.
Felts	One layer of asphalt-saturated asbestos felt weighing not less than 30 lb (perforated).
	Two layers of 15-lb asphalt-saturated asbestos felt (perforated).
Bitumen	60 lb for mopping between felts.
Surface Coat	1 gal roof coating or 25 lb of asphalt.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper lay one thickness of asphalt-saturated asbestos-base felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. Nail at 6-in centers through the laps and at 18-in centers through the longitudinal centers of each sheet in two lines spaced 10 in apart, the nails to be staggered. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof, mop two layers of 15-lb asphalt-saturated asbestos felts to the roof. Start with a one-half-width sheet, on top of which shall be mopped a full-width sheet so that the lower edge of the two sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 19 or 17 in for 36- or 32-in-width sheet, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

Each sheet shall be nailed along the back edge about 2 in from the edge at about 6-in centers.

The felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with the roof coating applied at the rate of not less than 1 gal per 100 sq ft or with a brush coat of asphalt at the rate of approximately 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for, they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

B. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from ½ in to 6 in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(for wood deck only) one layer red rosin paper.
Felts	One layer of asphalt-saturated asbestos felt weighing not less than 30 lb (perforated). Three layers of 15-lb asphalt-saturated asbestos felt (perforated).
Bitumen	90 lb for mopping between felts.
Surface Coat	1 gal roof coating or 25 lb of asphalt.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper lay one thickness of asphalt-saturated asbestos-base felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. Nail at 6-in centers through the laps and at 18-in centers through the longitudinal center of each sheet in two lines spaced 10 in part, the nails to be staggered. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof, mop three layers of 15-lb asphalt-saturated asbestos felt to the roof. Start with a one-third-width sheet, on top of which shall be mopped a two-thirds-width sheet, on top of which shall be mopped a full-width sheet so that the lower edge of the three sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 25 or 22 in for 36- or 32-in-width sheet, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

Each sheet shall be nailed along the back edge about 2 in from the edge at about 6-in centers.

The felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with the roof coating applied at the rate of not less than 1 gal per 100 sq ft or with a brush coat of asphalt at the rate of approximately 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this chapter.

ASPHALT-SATURATED ASBESTOS FELTS AND ASPHALT, SMOOTH SURFACE, OVER POURED CONCRETE, POURED GYPSUM, PRECAST CONCRETE SLABS OR OTHER NON-NAILABLE MATERIAL

A. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from ½ in to 6 in per ft.

Note: *On insulated steel roof decks, the manufacturer shall be consulted to obtain his recommendation as to thickness of insulation and its application to secure bond on the roofing material. Bond does not cover the insulation.*

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Concrete primer	1 gal.
Felts	One layer of asphalt-saturated asbestos-base felt weighing not less than 30 lb (perforated).
	Two layers of 15-lb asphalt-saturated asbestos felt (perforated).
Bitumen	90 lb for mopping between felts.
Surface Coat	1 gal of roof coating or 25 lb of asphalt.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roof deck is poured concrete or poured gypsum, coat the entire roof surface with concrete primer and allow it to dry thoroughly. Where the roof deck is precast concrete slabs, the primer shall be omitted for a width of 2 in on each side of all joints.

Second: Coat the entire roof surface with a mopping of hot asphalt at the rate of 30 lb per 100 sq ft and while hot, embed in it one thickness of asphalt-saturated asbestos-base felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends.

Third: Beginning at the low point of the roof, mop two layers of 15-lb asphalt-saturated asbestos felts to the roof. Start with a one-half-width sheet, on top of which shall be mopped a full-width sheet, so that the lower edge of the two sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 19 or 17 in for 36- or 32-in-width sheets, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between the sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

Fourth: Finish the entire roof surface with the roof coating applied at the rate of not less than 1 gal per 100 sq ft or with a brush coat of asphalt at the rate of approximately 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition, the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

COMBINATION BUILT-UP ROOF CONSISTING OF ASPHALT-SATURATED ASBESTOS AND RAG FELTS AND ASPHALT OVER NAILABLE DECKS—SMOOTH SURFACE

A. 10-YEAR SERVICE LIFE

For application over roof surfaces having an incline from 1 to 6 in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(for wood deck only) one layer red rosin paper.
Felt—base	One layer of asphalt-saturated rag felt weighing not less than 30 lb per 108 sq ft.
Felts, finishing	Two layers of 15-lb asphalt-saturated asbestos felts (perforated)
Bitumen	Not less than 55 lb of asphalt for mopping between felts.
Surface coat	1 gal of roof coating or brush coat of not less than 25 lb of asphalt.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 1, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper lay one thickness of asphalt-saturated rag felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. Nail at 6-in centers through the laps and at 18-in centers through the longitudinal center of each sheet in two lines spaced 11 in apart, the nails to be staggered. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof, mop two layers of 15-lb asphalt-saturated asbestos felt to the roof. Start with a one-half-width sheet, on top of which shall be mopped a full-width sheet so that the lower edge of the two sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 19 or 17 in for 36- or 32-in-width sheet, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

Each sheet shall be nailed along the back edge about 2 in from the edge at about 6-in centers.

The felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with the roof coating applied at the rate of not less than 1 gal per 100 ft or with a brush coat of asphalt at the rate of approximately 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for, they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

B. 15-YEAR SERVICE LIFE

For application over roof surfaces having an incline from 1 to 6 in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(For wood deck only) one layer of red rosin paper.
Felt, base	One layer of asphalt-saturated rag felt weighing not less than 50 lb per 108 sq ft.
Felts, finishing	Two layers of 15-lb asphalt-saturated asbestos felt (perforated).
Bitumen	Not less than 50 lb of asphalt for mopping between felts.
Surface coat	1 gal of roof coating or brush coat of not less than 25 lb of asphalt.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper lay one thickness of asphalt-saturated rag felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. Nail at 6-in centers through the laps and at 18-in centers through the longitudinal center of each sheet in two lines spaced 11 in apart, the nails to be staggered. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof, mop two layers of 15-lb asphalt-saturated asbestos felt to the roof. Start with a one-half-width sheet, on top of which shall be mopped a full-width sheet so that the lower edge of the two sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 19 or 17 in for 36- or 32-in-width sheet, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

Each sheet shall be nailed along the back edge about 2 in from the edge at about 9-in centers.

The felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with the roof coating applied at the rate of not less than 1 gal per 100 sq ft or with a brush coat of asphalt at the rate of approximately 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

C. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from 1 to 6 in per ft.

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft. of roof area:

Sheathing paper	(For wood deck only) one layer of red rosin paper.
Felt, base	One layer of asphalt-saturated rag felt weighing not less than 50 lb per 108 sq ft.
Felts, finishing	Three layers of 15-lb asphalt-saturated asbestos felts (perforated).
Bitumen	Not less than 75 lb of asphalt for mopping between felts.
Surface coat	1 gal roof coating or brush coat of not less than 25 lb of asphalt.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper lay one thickness of asphalt-saturated rag felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. Nail at 6-in centers through the laps and at 18-in centers through the longitudinal center of each sheet in two lines spaced 11 in apart, the nails to be staggered. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof, mop three layers of 15-lb asphalt-saturated asbestos felt over the base felt, start with a one-third-width sheet, on top of which shall be mopped a two-thirds-width sheet, on top of which shall be mopped a full-width sheet so that the lower edges of the three sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 25 or 22 in for 36- or 32-in-width sheets, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between the sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

Each sheet shall be nailed along the back edge about 2 in from the edge at about 6 in centers.

The felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with the roof coating applied at the rate of not less than 1 gal per 100 sq ft or with a brush coat of asphalt at the rate of approximately 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for, they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

DEAD-LEVEL ROOFING CONSISTING OF ASPHALT-SATURATED ASBESTOS FELTS AND SPECIAL ASPHALT OVER NAILABLE DECKS—SMOOTH SURFACE

A. 15-YEAR SERVICE LIFE

For application over roof surfaces having an incline from dead level to ½ in per ft.

1. Materials

This roof shall contain not less than the following quantities of material per 100 sq ft of roof area:

Sheathing paper	(For wood deck only) one layer of red rosin paper.
Felt, base	One layer of asphalt-saturated asbestos felt weighing not less than 30 lb per 108 sq ft.
Felts, finishing	Two layers of 15-lb asphalt-saturated asbestos felts (perforated).
Bitumen	Not less than 50 lb of special dead-level asphalt for mopping between felts.
Surface coat	Not less than 25 lb of the above bitumen applied as a brush coat.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Information, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper lay one thickness of asphalt-saturated asbestos felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. Nail at 6-in centers through the laps and at 18-in centers through the longitudinal center of each sheet in two lines spaced approximately 11 in apart, the nails to be staggered. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof, mop two layers of 15-lb asphalt-saturated asbestos felt to the roof. Start with a one-half-width sheet, on top of which shall be mopped a full-width sheet so that the lower edge of the two sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 19 or 17 in for 36- or 32-in-width sheet, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of not less than 25 lb per 100 sq ft of roof surface.

Each sheet shall be nailed along the back edge at 2 in from the edge at 9-in centers.

The felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with a brush coat of special asphalt at the rate of not less than 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

B. 20-YEAR SERVICE LIFE

For application over roof surfaces having an incline from dead level to ½ in per ft.

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Sheathing paper	(For wood deck only) one layer of red rosin paper.
Felts, base	One layer of asphalt-saturated asbestos felt weighing not less than 30 lb per 108 sq ft.
Felts, finishing	Three layers of 15-lb asphalt-saturated asbestos felts (perforated).
Bitumen	Not less than 75 lb of special dead-level asphalt for mopping between felts.
Surface coat	Not less than 25 lb of above bitumen applied as a brush coat.
Accessories	Nails, tin disks, etc.

2. Application

The specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roofing is to be applied over a wood deck, lay one thickness of sheathing paper (red rosin), lapping the sheets not less than 1 in and nailing as often as necessary to hold in place.

Second: Over the sheathing paper lay one thickness of asphalt-saturated asbestos felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. Nail at 6-in centers through the laps and at 18-in centers through the longitudinal center of each sheet in two lines spaced approximately 11 in apart, the nails to be staggered. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof, mop three layers of 15-lb asphalt-saturated asbestos felt over the base felt, starting with a one-third-width sheet, on top of which shall be mopped a two-thirds-width sheet, on top of which shall be mopped a full-width sheet so that the lower edges of the three sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 25 or 22 in for 36- or 32-in-width sheet, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between sheets shall be at the rate of not less than 25 lb per 100 sq ft of roof surface.

Each sheet shall be nailed along the back edge 2 in from the edge at 9-in centers.

These felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with a brush coat of special asphalt at the rate of not less than 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for, they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

DEAD LEVEL ROOFING CONSISTING OF ASPHALT SATURATED ASBESTOS FELTS AND SPECIAL ASPHALT OVER NON-NAILABLE DECKS—SMOOTH SURFACE

A. 20-YEAR-SERVICE LIFE

For application over roof surfaces having an incline from dead level to ½ in per ft.

Note: *On insulated steel roof decks, the manufacturer shall be consulted to obtain his recommendation as to thickness of insulation and its application to secure bond on the roofing material. Bond does not cover the insulation.*

1. Materials

This roof shall contain not less than the following quantities of materials per 100 sq ft of roof area:

Concrete primer	1 gal.
Felts, base	One layer of asphalt-saturated asbestos-base felt weighing not less than 30 lb (perforated).
Felts, finishing	Two layers of 15-lb asphalt-saturated asbestos felt (perforated).
Bitumen	Not less than 90 lb of special dead-level asphalt for mopping between felts.
Surface coat	Not less than 25 lb of above asphalt applied as a brush coat.

2. Application

The specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter, shall be considered a part of this specification.

First: If the roof deck is poured concrete or poured gypsum, coat the entire roof surface with concrete primer and allow it to dry thoroughly. Where the roof deck is precast concrete slabs, the primer shall be omitted for a width of 2 in on each side of all joints.

Second: Coat the entire roof surface with a mopping of hot asphalt at the rate of 30 lb per 100 sq ft and while hot, embed in it one thickness of asphalt-saturated asbestos-base felt, lapping each sheet 2 in at the edges and not less than 6 in at the ends. The felt shall be turned up not less than 4 in along all vertical surfaces.

Third: Beginning at the low point of the roof mop two layers of 15-lb asphalt-saturated asbestos felts to the roof. Start with a one-half-width sheet, on top of which shall be mopped a full-width sheet, so that the lower edge of the two sheets are even with the edge of the roof.

The remaining sheets, all full width, shall each lap 19 or 17 in for 36- or 32-in-width sheets, respectively, mopping with asphalt the full width of each sheet so that in no place shall felt touch felt. Moppings between the sheets shall be at the rate of 30 lb per 100 sq ft of roof surface.

These felts shall be cut off at the angle of the roof deck and walls and at vertical surfaces.

Fourth: Finish the entire roof surface with a brush coat of special asphalt applied at the rate of not less than 25 lb per 100 sq ft.

3. Flashings

Flashings shall be installed at all intersections of the roof with vertical surfaces, and the plans shall show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for they shall be furnished and installed in accordance with specifications for Sheet Metal Work, Part 11, this Chapter, and in addition, the felt and bitumen reinforcement shall be applied as detailed under the specifications for Built-Up Roofing and Flashing—General Conditions, Part 10, this Chapter.

Report on Assignment 5

Expansion Contraction and Control Joints In Concrete and Masonry Block Buildings

S. M. Bielski (chairman, subcommittee), W. F. Armstrong, G. J. Bleul, T. J. Engle, W. G. Harding, T. M. Kelly, S. E. Kvenberg, G. H. McMillan, J. D. Moore, Jr., G. A. Morison, W. C. Panarese, J. T. Schoener, R. C. Smith.

Your committee submits the following final report as information.

Synopsis

The cracking of walls constructed of concrete masonry is regarded as one of the major problems in the use of masonry units. This report summarizes an investigation made of the voluminous literature available covering the various theories relative to cracking in concrete masonry construction and means to help prevent cracking. No single recommendation regarding the positioning and spacing of control joints in masonry walls can be applied to all structures because it would depend upon such factors as length of walls, architectural details and local experience.

Each building design should be analyzed to determine potential wall movements, and control joints should be provided to relieve excessive stresses that might be expected to result from such movement. If control joints are used where points of weakness are expected, cracking can be regulated in a satisfactory and acceptable manner. Fractures in concrete masonry will rarely occur, if at all, when high-quality concrete block are used and when good construction practices, embodying effective control-joint procedures, are followed in conjunction with structurally adequate design and proper architectural details.

Introduction

A more appropriate title for this assignment would be "Cracks and Control Joints in Concrete Masonry Buildings." In masonry construction the term "control joint" is applicable to either expansion or contraction joints. Control joints relieve compressive stresses that may develop when concrete expands by providing space into which adjacent portions of the structure may move. Tensile stresses caused by a decrease in volume of the concrete due to drying are also relieved by control joints. The present title may be misconstrued to include joints in architectural concrete buildings, whereas the assignment was intended to cover only concrete masonry, which is a term applied to block, brick and tile building units molded from concrete and laid by masons.

Concrete masonry units, commonly referred to as concrete block, are made of portland cement and inert aggregates such as sand, gravel, crushed stone, cinders, burned clay or shale, pumice, air-cooled or expanded blast-furnace slag, and other suitable aggregates. Concrete block have many advantages. They are durable, relatively low in cost, produced in sizes which permit rapid laying in mortar, highly resistive to fire, and available in practically every locality. The advantages, however, are at times offset by the tendency of concrete masonry walls to develop cracks which are unsightly and may permit water leakage through the wall.

Causes of Masonry Cracking

Recent investigations of the causes of masonry wall cracking indicate that one factor contributing to the cracking of masonry walls is thermal expansion and contraction. It may be questioned why greater provision must be made for thermal movement of modern masonry walls than was required for masonry walls 100 to 400 ft in length which were built several decades ago without control joints. The older walls have been exposed to severe temperature changes over a period of years without evidence of cracking which might be attributed to thermal expansion. Today there are a number of reasons for greater provisions for thermal movement.

1. *Thin Walls.* During the past 20 years, the thickness of masonry walls as required by building codes has been reduced. This is particularly true of non-load-bearing curtain and spandrel walls; however, to a lesser degree, it is also true of bearing walls. Temperature variations in thin walls are greater than those in thick walls, due primarily to the differences in heat storage capacities.

2. *Insulation.* With the increased use of air conditioning, insulation materials are frequently applied to masonry walls to reduce heat transmission. As a result, wall temperature variations on the "cold" side of the insulation are greater than for uninsulated walls.

3. *Composite Walls.* Many masonry walls as now constructed consist of brick with hollow backup units, such as structural clay tile or concrete block. Thermal characteristics of brick facing differ from those of the backup, particularly concrete block, which result in differential thermal movement.

4. *Sills, Lintels, etc.* Thermal characteristics of cast stone sills and trim differ from those of concrete masonry, and the coefficient of expansion of metal lintels, window and door frames is substantially greater than that of concrete masonry. This may cause relatively large differential movement, particularly between metal and masonry.

To control movements in masonry walls resulting from various types of stresses, increasing use is being made of control joints. Control joints are nothing new in the construction industry. They have been used for years in concrete highway construction and in architectural concrete work. The placement of control joints where they become part of the architectural treatment has been, from the beginning, a basic principle of architectural concrete design. Control joints as applied to masonry walls are continuous vertical joints built into the walls at points where stresses might concentrate.

All types of masonry units and masonry wall construction are subject in varying degrees to cracking from the following causes, acting separately or in combinations:

1. Unequal settlement or distortion of the foundations supporting masonry construction.
2. Overstressing of masonry caused by external forces of unexpected severity which may occasionally develop from earth pressure, earthquakes, hurricanes, etc.
3. Abnormal distortion, especially expansion, of appurtenant elements such as floors and roofs.
4. Volume changes in masonry involving principally temperature shrinkage and moisture shrinkage.

In recent years, emphasizing the importance of properly designed footings and wall sections, along with substantial improvements in concrete masonry manufacturing processes, has proven helpful in reducing the frequency of cracks in concrete masonry. However, laboratory investigations of concrete masonry have indicated that volume change, an inherent characteristic of concrete, is the important factor remaining uncontrolled as far as the incidence of cracking is concerned. This factor will be further discussed later.

When foundation walls are exposed to a height of more than a foot or so above grade, thermal changes cause cracking in the foundations. The stresses developed are transferred to the masonry above, and it also cracks. Frequently, such cracks are erroneously identified as settlement cracks. These cracks are of uniform width throughout the exposed foundation height, whereas settlement cracks can be identified by their position and by the fact that they are wider at the top or bottom, depending upon their location in the foundation.

A variation in temperature of 100 F may cause a change in length of as much as 5/8 in. in a masonry wall 100 ft long. This change in length sets up stresses in the wall which are likely to cause cracking around wall openings or where walls abut or story heights change.

Cracks are sometimes caused by inferior mortar or, when mortar is of good quality, poor workmanship may result in uneven and insufficient mortar bedding. Since water penetration through a wall can cause serious problems, a well filled mortar joint is important. Workable plastic mortar is preferable to dry stiff mortar. Mortar must be sticky so that it will adhere to the block and have good bonding quality.

Relation of Materials to Cracking

It is important to consider what effect, if any, the masonry units may have on cracking. A characteristic of all portland cement concrete, including concrete masonry units, is the tendency to decrease in volume with either a decrease in moisture content or a decrease in temperature. This decrease in volume may result in shrinkage cracks when concrete masonry is restrained from shrinkage.

The control of cracking in masonry construction begins at the plant where the block is manufactured. Shrinkage of block units is affected by the proper selection and proportioning of the materials used. Cement, aggregates, water and additives all play a vital role in the control of cracking. It is well known that unclean or high-clay-content sands will not make good block. The use of additives in small quantities may be beneficial, but when used improperly or in excess, they can be detrimental. Proper mixing, curing and the correct amount of water are very important.

A sharp distinction must be made between shrinkage cracks caused by faulty design and construction and those caused by properties of the building material. A further distinction must be made between shrinkage cracks caused by using poor materials for the manufacture of concrete masonry units and shrinkage cracks caused by poor manufacturing procedures. In the past few years many claims have been made as to the relative merits of various manufacturing procedures and their effect on shrinkage cracking. Quite logically, it may be expected that the following features in the manufacture of concrete masonry units influence shrinkage cracking: (1) gradation of aggregate, (2) chemical and physical properties of aggregate, (3) chemical and physical properties of portland cement, (4) mix proportion (aggregate, cement and water), (5) method of curing and (6) design of the unit.

From the results of investigations made by various agencies it is concluded that shrinkage varies considerably, depending on the type of aggregate used and also on the method of curing. In general, shrinkage is inversely proportional to the weight of the unit, with some minor exceptions. Sand- and gravel-aggregate units, the heaviest tested, showed the least shrinkage. Pumice-aggregate units, the lightest tested, showed the greatest shrinkage. Cinder, expanded shale, expanded slag, and sintered-shale-aggregate units, in general, showed approximately the same shrinkage, which was greater than that shown by sand and gravel units and less than that shown by pumice units.

Curing and Drying of Masonry Units

Equally important to the proper use of aggregates and the proper proportioning and mixing of the concrete materials is the curing of the finished units. Information from various sources shows that cracking in concrete masonry walls can be reduced by minimizing moisture shrinkage in the wall. Various specifications have been written in attempts to reduce the amount of free water in the block and thus reduce the total amount of drying shrinkage and cracking in masonry walls. Shrinkage is greatly reduced with proper curing and drying of the blocks so that when placed in the wall, their moisture content is in equilibrium with the surrounding air. This precaution will assist in minimizing subsequent volume changes and enable the tensile strength of the block to overcome these internal stresses. The acceptable moisture content of cured block is limited in both the federal and ASTM specifications to 40 percent of their total absorption. The Corps of Engineers requires that the moisture content be no more than 30 percent of total absorption. It is very important that blocks comply at least with the moisture content of these specifications.

The volume change or drying shrinkage of concrete block is generally considered to be a function of the blocks' moisture content. Furthermore, concrete block are subject to gain or loss of moisture, depending directly upon the moisture conditions or relative humidity of the air to which they are exposed. The degree of dryness will vary, but for any given locality the concrete should be in an air-dry condition corresponding to the average annual relative humidity of the outside air for the locality. This principle applies to all types of concrete masonry units regardless of what type aggregate or method of curing is used. A rapid method and simple apparatus has been developed by the Portland Cement Association for determining the moisture condition of concrete block in terms of relative humidity. This method is described in ASTM designation C 427.

Some place along the line from raw material to finished product, all concrete masonry units go through a period of shrinkage. Concrete units shrink as they are being cured and while drying. Obtaining complete shrinkage of a masonry material is an important part of the manufacturing process, and the unit is not a finished product until a large part of this shrinkage has occurred. The big problem is that all too frequently the block made today is shipped to the job tomorrow. Chances of not developing cracks in a block of this type are very slim.

Present-day production of block utilizes either low-pressure or high-pressure steam curing. High-pressure steam curing (HP), or autoclave, refers to curing of concrete masonry units by live steam at moderate pressures, usually 125 to 150 psi. Low-pressure steam curing (LP) refers to the curing of concrete masonry units with live steam at atmospheric pressure. The technique is sometimes described as atmospheric steam curing since the curing chamber is under no relative pressure.

High-pressure steam curing of masonry units reduces shrinkage by approximately one-half compared with other curing methods, except for pumice-aggregate units where the reduction in shrinkage is approximately one-third.

After the steam-curing period another equally important operation is essential—that of allowing the units to air dry. Where possible, units should be stored under cover and should be piled in narrow stock piles with cells horizontal and opposite so that the air can circulate freely through the piles. They should not be stored in contact with the ground where they will reabsorb moisture. During rainy weather they should be protected by tarpaulins or by storage within a building. Units which become wet should not be used until they are dried, and this may be accomplished by stacking them under cover for at least a week.

Carbonation

Carbonation is a chemical change which takes place within the concrete when it absorbs carbon dioxide from the air. Carbonation can cause shrinkage in individual masonry units and in walls constructed of them. This is a new concept in the volume change of block. Formerly volume change was considered to result entirely from changes in moisture content or temperature. Carbonation shrinkage appears to be of lesser importance in dense concrete. Presumably the higher permeability of concrete for masonry units makes the cement paste more readily available to the action of atmospheric carbon dioxide, so that carbonation can progress more rapidly and more nearly to completion in block than in dense concrete.

At the present time little is definitely known about the fundamental mechanism of carbonation—exactly what constituents of the cement paste are involved, what reaction products are formed, or how this process results in shrinkage. It appears that the rate of

reaction depends largely upon the moisture content of the block, and therefore upon the relative humidity of the atmosphere. It is likely that it depends also upon density of cement paste, extent of cement hydration, and other factors not yet fully understood. The problem of shrinkage in individual concrete masonry units is more complex than was once thought.

One of the more obvious differences between carbonation shrinkage and drying shrinkage is that carbonation tends to cause an increase in weight of the concrete, whereas drying tends to cause a decrease. It is possible for both processes to take place simultaneously. If moisture loss is proceeding rapidly and carbonation slowly, the units will lose weight. If carbonation is proceeding rapidly and moisture loss slowly, they will gain weight. Furthermore, under certain conditions, such peculiar effects might be observed as (a) an increase in weight while the length remains the same, caused by the appropriate rate of moisture gain while carbonation occurs, or (b) a decrease in length while the weight remains the same, caused by the appropriate rate of moisture loss while carbonation occurs. The total amount of shrinkage that can be caused by carbonation may be greater than that caused by moisture loss. Because of its newly discovered importance, the subject of carbonation is receiving continued study with the hope that some beneficial practical solution may be achieved.

Bond Beams and Joint Reinforcement

In the majority of cases bond beams and joint reinforcement are used primarily for crack-control purposes and to preserve rather than increase the flexural strength of walls. In the event that vertical cracking should develop and impair the strength of masonry, then bond beams and joint reinforcement become effective.

On extremely high walls bond beams are a must, but when used for controlling cracks, their effect diminishes as the distance from the bond beam increases. Hence, to get good and adequate control of cracking, a bond beam would be required every few feet, making this method of controlling masonry cracking impractical.

An effective method of controlling cracking in masonry walls is the use of joint reinforcement which serves the same purpose in concrete masonry mortar joints as welded wire mesh in concrete slabs; it reduces the possibility of cracking at points of strain where failures are most likely to occur. The use of joint reinforcement will not eliminate cracking entirely in block walls, but will disburse the large crack into small, minute cracks usually not detected with the naked eye.

How often should joint reinforcement be used? Under average conditions when used without control joints or bond beams, joint reinforcement should be used in every second course and in at least two consecutive courses above and below all wall openings. Reinforcement in the latter case should extend at least 32 in on each side of the opening. When building a high wall, reinforcement should be used in the same manner with the addition of a bond beam every 12 ft of vertical height. When used in conjunction with control joints at 30 ft spacing, reinforcement need only be used every fourth course with reinforcement ending at the control joint. On walls less than 15 ft in length, reinforcement need only be used above and below window or door openings.

Location and Spacing of Control Joints

The decision whether to specify control joints should be made by the engineer or architect on the basis of past and current performance of the block to be used with respect to the actual amount of cracking in structures of various types. In many in-

stances, control joints are specified without giving any consideration to the past performance of the block to be used, thus increasing construction cost without any apparent structural advantage.

Architects and engineers are giving more consideration to the use of control joints in masonry construction. These joints allow for any slight wall movement resulting from contraction or other stresses and relieve the strain which may ultimately develop cracking.

No single recommendation regarding the positioning and spacing of control joints can be made applicable to all structures. There is no hard and fast rule, and no truly sound or accurate theoretical law. Good common sense, applied after a thorough study of the building, will dictate the most probable necessary locations. Walls should be divided by joints into rectangular panels where possible and panels with re-entrant angles should be avoided. The following "recommendations" are suggested as a guide:

1. With an unreinforced concrete masonry wall, without openings or columns and supporting a roof, there is a relationship between the height of the wall and the spacing of control joints. This relationship or spacing of control joints is approximately 1¼ times the wall height. For example, a wall 12 ft high would require 15-ft control-joint spacing (Fig. 1).

2. When concrete masonry is used as backup to clay or stone masonry facing materials, control joints can be spaced farther apart, with a maximum spacing between joints of two times the wall height. The joint should extend completely through the wall thickness including the facing material. Plaster applied over lath and furring does not require vertical separation at control joints. Where plaster is applied directly to a concrete masonry wall, a bull-nose mold or flexible joint cover should be used in the plaster at control joints.

3. At all abrupt changes in wall height, a concentration of stresses will likely occur and control joints should be placed at these points (Fig. 2).

4. Where cast-in-place foundations have joints, the joints should be continued up through the concrete masonry walls with a control joint (Fig. 3). Similarly, expansion joints in roof slabs should be continued down through the masonry wall (Fig. 4).

5. Where the thickness of the wall changes abruptly, such as at the junction of a single-story wing to a multi-story building, at columns, chases for pipes or ducts, pilasters, etc., a stress concentration occurs which must be relieved by a control joint. The space

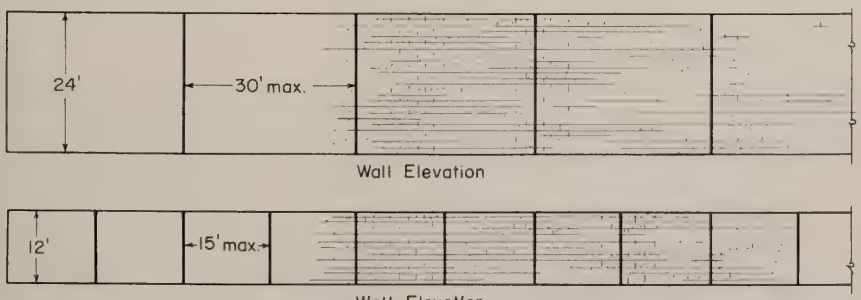
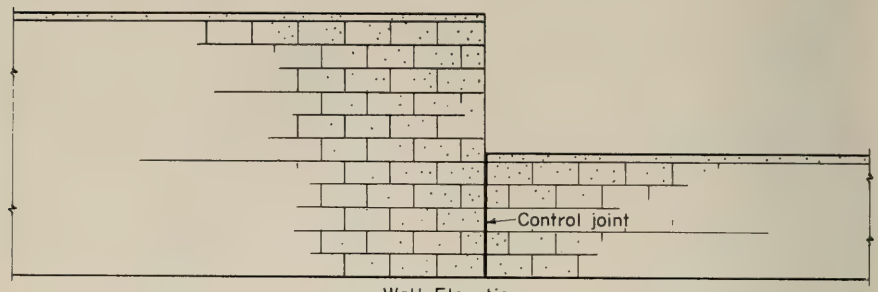


FIG. 1-SPACING OF CONTROL JOINTS VARIES WITH WALL HEIGHT

$S = 1\frac{1}{4} \times h$ (max)



Wall Elevation

FIG. 2 - LOCATION OF CONTROL JOINTS AT CHANGE IN WALL HEIGHTS

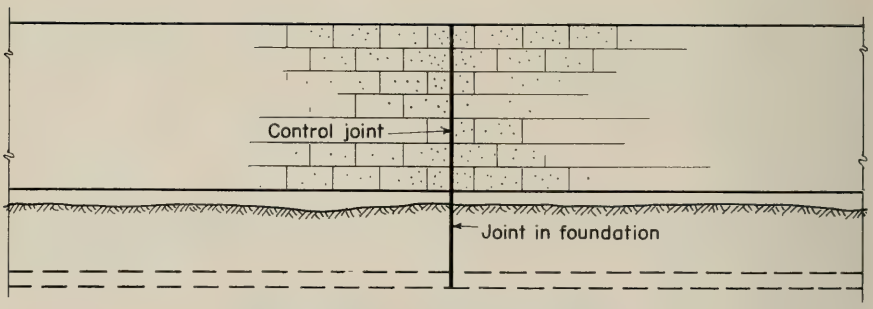


FIG. 3 - LOCATION OF CONTROL JOINTS ABOVE JOINTS IN FOUNDATION

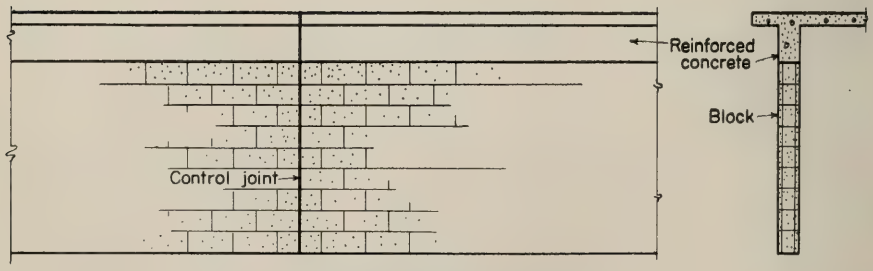


FIG. 4 - LOCATION OF CONTROL JOINTS BELOW JOINTS IN ROOF

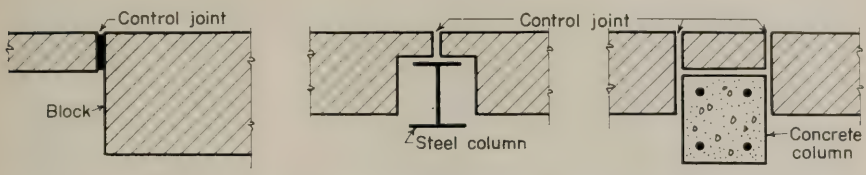


FIG. 5 - LOCATION OF CONTROL JOINTS AT CHANGES IN WALL THICKNESS

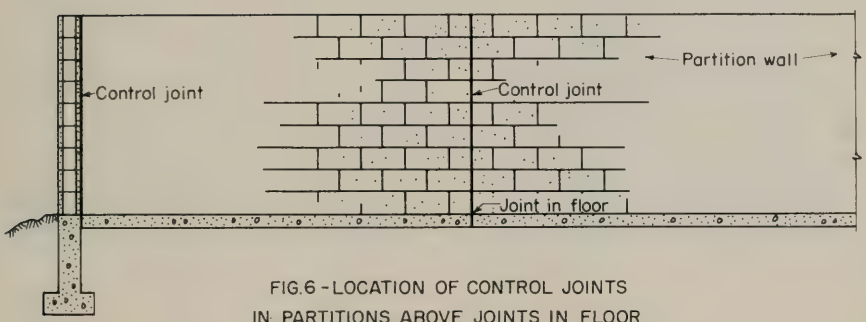


FIG. 6 - LOCATION OF CONTROL JOINTS IN PARTITIONS ABOVE JOINTS IN FLOOR

between the columns and the masonry should not be filled with mortar as this does not free the joint, and cracking is likely to occur (Fig. 5).

6. Interior partitions should be provided with control joints at intersections with other walls and partitions, at openings and in general the same rules apply as for other walls. A joint should be provided over joints in concrete floors (Fig. 6).

7. All openings in walls should be recognized as natural and desirable joint locations. Although some adjustment in the joint pattern established for the wall may be required, the desirability of including vertical sides of wall openings as part of control-joint construction makes such an adjustment mandatory in the development of a completely effective arrangement of control joints. Below windows the joints usually are extended directly below the sides of the openings. Above doors and windows the joints must be offset to the end of the lintels. The bearing at the ends of the lintels should not be bonded to the masonry in order to permit movements. It is recommended that openings less than 6 ft wide have a control joint along only one side of the opening. Wider openings, 6 ft or more, should have joints along both sides (Fig. 7 and 8).

8. Intersecting walls should never be tied together with a masonry bond. To do so forms a point of restraint, with the walls trying to move transversely to each other. One wall should terminate at the face of the other wall with a control joint at that point. If it is necessary for the walls to be tied together for mutual support and stability, ¼-in-mesh hardware cloth (Fig. 9) or a tiebar ¼ in thick, 1¼ in wide and at least 24 in long with 2-in right-angle bends at each end (Fig. 10) can be used to provide the support without restraining the walls from moving.

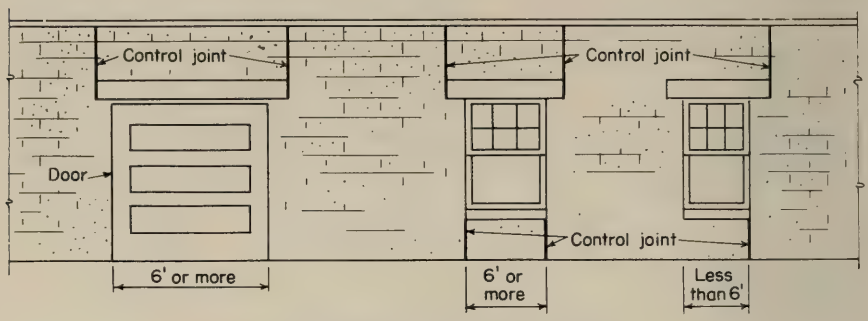


FIG. 7 - LOCATION OF CONTROL JOINTS AT DOORS AND WINDOWS

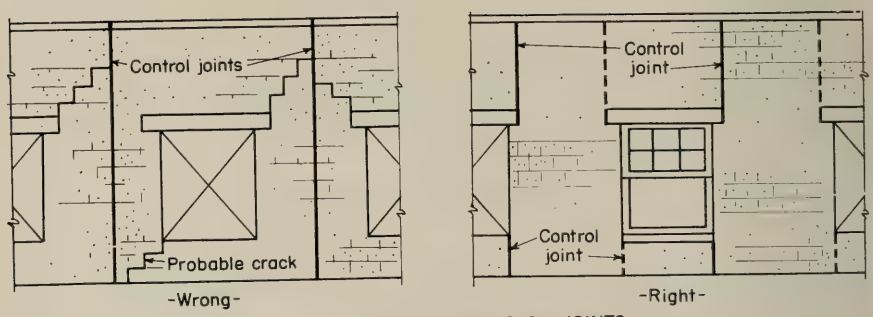


FIG. 8 - LOCATION OF CONTROL JOINTS

9. Masonry block walls which meet, such as at corners of exterior building walls or at corners in corridor walls, etc., should be laid up in true masonry bond. However, corners form points of restraint, and a control joint should be located in each of the two walls, close to the corner and preferably at the nearest door or window opening. The maximum distance however from the corner to these control joints should not be more than that equal to the height of the wall.

10. When concrete masonry walls are reduced in thickness across the face of columns, a control joint should be placed along both sides of the column. The thin concrete masonry across the face of the column should be tied to the column by means of dovetail anchors (Fig. 11).

11. To avoid the occurrence of cracks due to differential movement between concrete masonry and structural steel framing members, such as columns, a space should be allowed between the masonry and the member to allow free movement. A control joint should be located at the center of the vertical framing member and spaced to coordinate with the control joint pattern established for adjoining walls.

12. Because the temperature and moisture content of concrete block below grade in foundation walls are usually quite constant and because it is quite difficult to construct a watertight control joint in masonry, control joints are not recommended for basements or foundation walls except where required by, and alined with, control joints

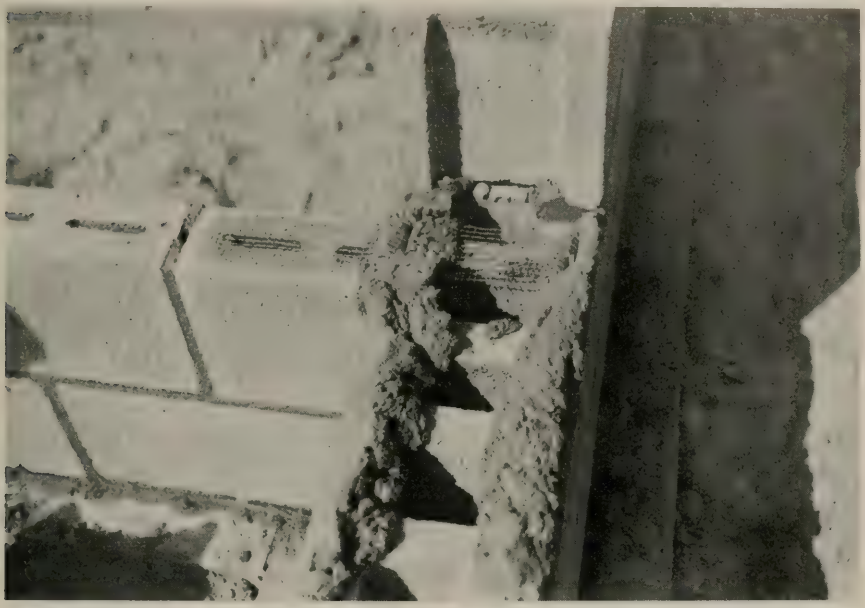


Fig. 9—For tying nonbearing block walls to other walls, strips of metal lath or ¼-in-mesh galvanized hardware cloth are placed in alternate courses across the joint between the two walls.

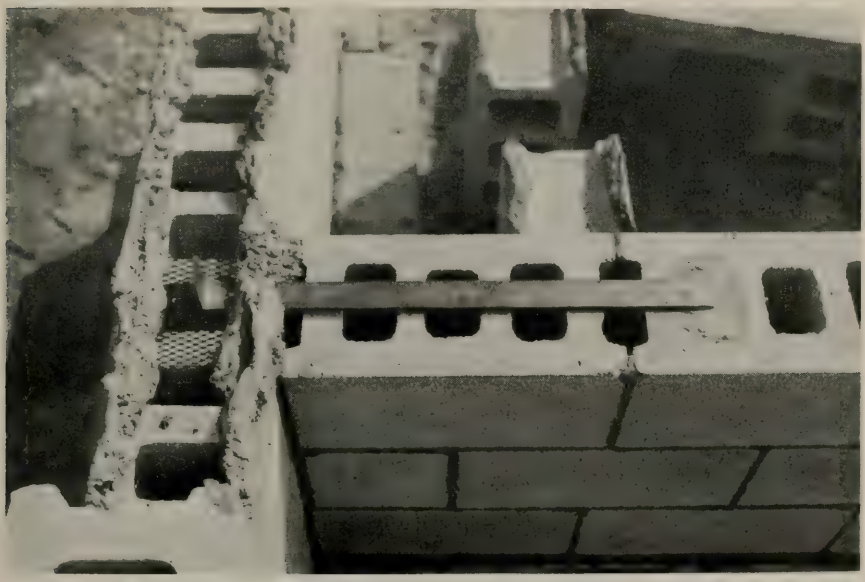


Fig. 10—For tying bearing block walls to other walls, metal tiebars ¼ in thick, 1¼ in wide and 24 in long, with 2-in right-angle bend on each end, are placed not over 4 ft apart vertically.

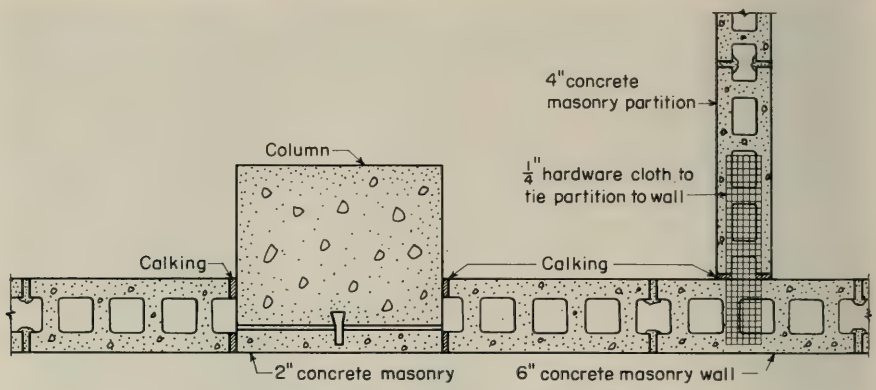


FIG. 11 -DETAIL OF BLOCK AT COLUMN
AND METHOD OF TYING PARTITION TO WALL

in the superstructure. To permit unrestrained movement at control joints, a longitudinal slip plane should be provided, wherever structurally practicable, between control-jointed wall sections and supporting foundations.

In general, a control joint should be carried completely through the superstructure (that is, everything above grade), but not necessarily through a slab on-grade or through the foundation. The reasons for this are that the superstructure is exposed and subject to extreme changes in temperature, while slabs on-grade and foundations are protected by the building and ground and are exposed to relatively constant temperatures. Also, a slab on-grade will usually have adequate construction joints. However, it is probably advisable to carry a joint through a structural slab, at the location of a joint through the superstructure, as well as planning a joint through the foundation wall at the same location.

Types of Control Joints

The two most popular ways of constructing control joints are the special tongue-and-groove block control joint and the regular open-end block with mortar key, often referred to as the Michigan type of control joint.

The special tongue-and-groove block (Fig. 12) is made in sets consisting of one 8- by 8- by 16-in and one 8- by 8- by 8-in half block. The tongue will fit into the opposite end of another special control joint block or into the open end of a regular stretcher. The block are laid in mortar exactly as any other block, including mortaring the head joint (Fig. 13). This is done so that the mason can maintain his bond more easily and also part of the mortar is allowed to remain in the vertical joint to form a backing against which the caulking can be packed. The tongue-and-groove block provides excellent lateral stability to the wall.

The Michigan control joint uses regular open-end block. The block are laid to a vertical joint using two half block in every other course. A strip of building paper is then curled into the end core covering the end of the block on one side of the joint. As the block on the other side of the joint is laid, the core is filled with mortar or concrete. The filling bonds to one block, but the paper prevents bond to the block on the other side of the control joint. Thus the control joint can move longitudinally while the mortar plug transmits transverse loads (Fig. 14).

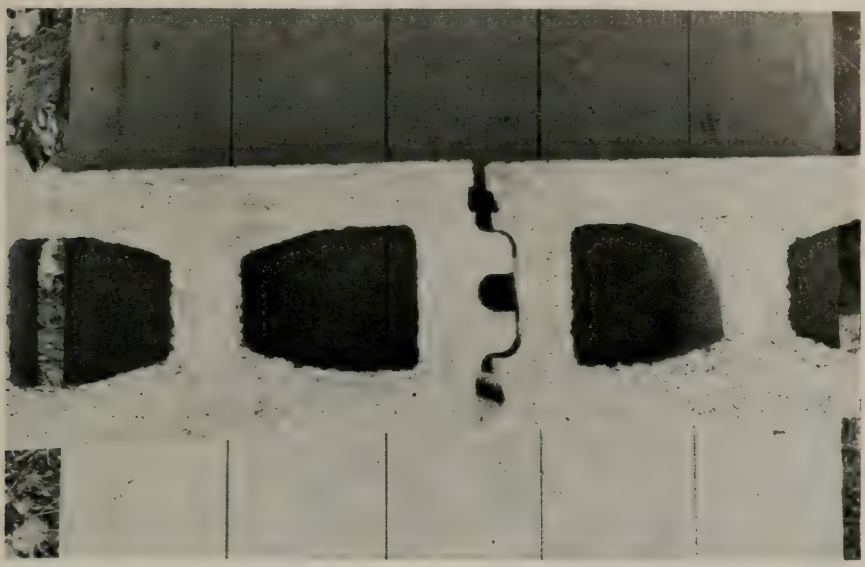


Fig. 12—A special control-joint block provides lateral support by means of tongue-and-groove ends of the block.

Fig. 13—Tongue-and-groove control joint block are made in full- and half-length units.

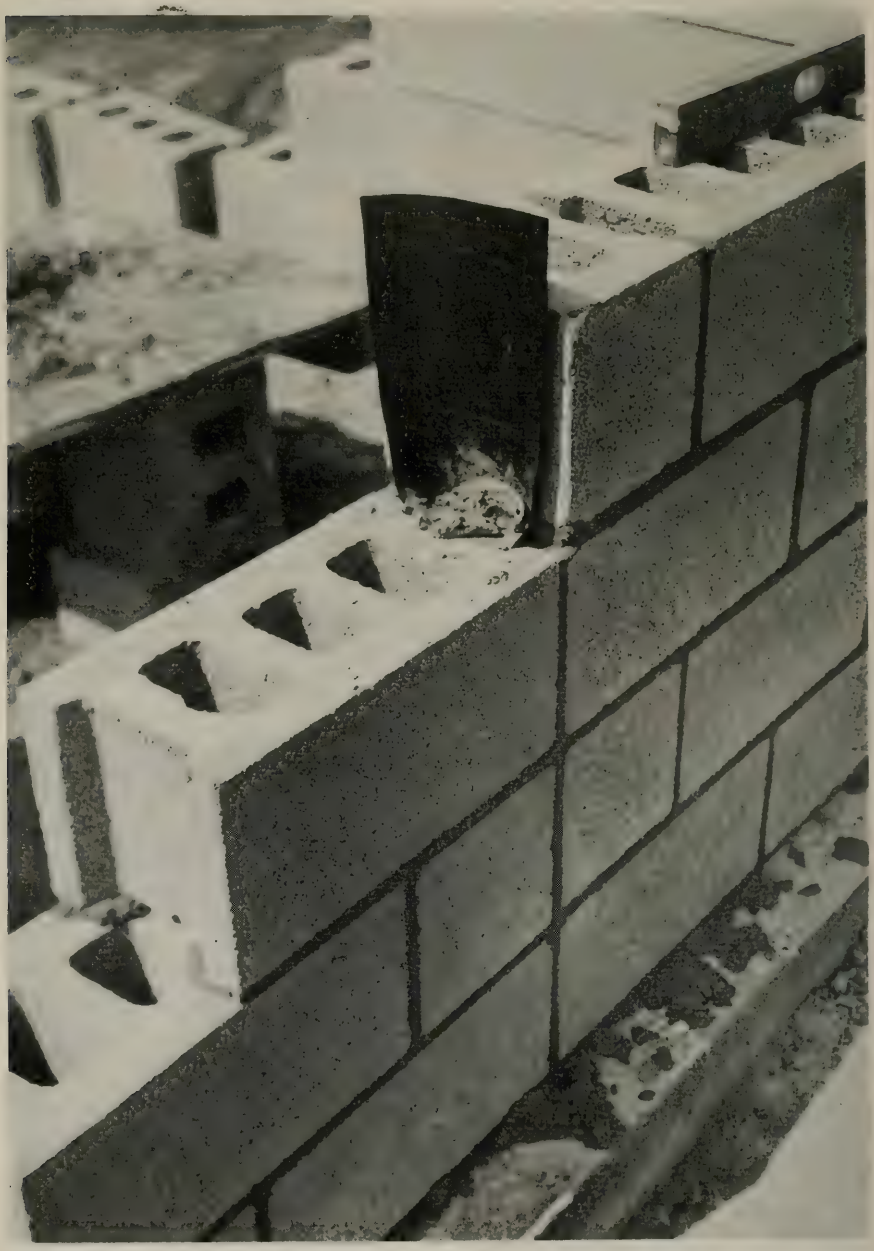


Fig. 14—The Michigan control joint uses regular open end block with a mortar key for lateral support.

To keep control joints as unnoticeable as possible, care must be taken to build them plumb and of the same thickness as other mortar joints. Control joints should be laid up in mortar just as any other vertical joint.

All control joints that are to be exposed to the weather or to view should be sealed with an elastic caulking compound. If the joint is to be caulked, a recess is provided for the caulking material by raking out the mortar to a depth of ¾ in before it has become too hard (Fig. 15). A pointing trowel or a special wheeled rake can be used for this purpose. To prevent the dry block from absorbing oils from the caulking compound and thus causing it to harden, the inner faces of the joint should be primed with shellac, aluminum paint or other sealer. Recommendations of manufacturers of caulking compounds regarding proper priming should be followed. The caulking is then applied, using knife-grade compound and a pointing trowel (Fig. 16) or by using a caulking gun. Care must be taken not to smear the compound onto the faces of the block.

Maintenance of Joints

The principal maintenance operation required in connection with joints is the renewal of caulking. Compounds which are properly installed during construction will function satisfactorily for several years. They do require periodic inspection, since the failure of the caulking may lead to eventual failure of a joint due to infiltration of water, soil, and other extraneous material into the joint space.

When inspection determines that the existing caulking must be replaced, the joint space must be cleaned of all foreign matter, including the old compound. After the joint space is thoroughly clean and dry, new joint caulking is applied in the same manner as for new construction.

Conclusions

Although control joints are advocated for use to minimize cracking due to movements which tend to take place in concrete masonry walls, they are expensive, require maintenance and often are unsightly if not properly installed. They should therefore be limited in use as far as practical. It is highly desirable that the architect, engineer and contractor continually insist on the use of only those materials which meet the specifications and that they adhere strictly to approved practices during construction in order to obtain crack-free concrete masonry structures.

Where local experience indicates it is necessary to use control joints to obtain a successful concrete masonry structure, close cooperation between the architect and structural engineer is important and necessary to assure both a workable and an attractive arrangement of control joints. The designer should anticipate where high concentration of stresses might occur and provide for joints at these locations. Ordinarily, joints are placed at openings in walls, such as doors and windows, at abrupt changes in wall height or thickness, at columns and pilasters and at intersecting walls. Control joints should divide the wall area into rectangular shapes as much as possible to eliminate localized stresses.

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Fig. 15—Mortar is raked out to depth of about ¾ in to provide a recess for calking all control joints exposed to weather or view.

Fig. 16—A thin, flat calking trowel can be used to force calking compound into the joint.

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Report on Assignment 7

New Structural Systems for Railway Buildings

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Your committee submits as information the following progress report, which covers new types of masonry construction only. The committee is continuing its study of new types of construction using other materials and will present the information developed in future reports.

INTRODUCTION

In the past few years many new types of construction have been developed which combine pleasing appearance with efficient use of newly developed materials. Many of these newer types of construction use lighter sections, yet have the same strength as earlier, much heavier types of construction. Greater use is being made of prefabrication and mass production, which reduce the cost of materials, and minimize the amount of skilled construction labor necessary for erection work. In the face of rising construction costs, the use of these new systems is advantageous to the railway industry.

In masonry construction, many advances have been made. Presented below is a description of new types of masonry construction which may be applicable to railway buildings.

A. MASONRY

1. Concrete

a. Prestressed Concrete Construction

Prestressed concrete construction has rapidly moved into prominence in the building field since the end of World War II. Because columns, beams, girders and roof and floor slabs are precast and then set in place, forming on the job is almost eliminated. Most larger cities and many of the smaller ones now have precasting and prestressing plants where members are cast, tensioned and then transported to the job site. Over 5000 such plants are now operating in the United States. On large projects, the contractor usually sets up a casting plant on the job site. Prestressed concrete construction uses high-strength concrete with reinforcement in the form of high-strength steel wire used singly or in cables. The prestress in the reinforcement may be applied by first stretching the wires or cables and casting the concrete around them. When the concrete has reached its specified compressive strength, the initial stress in the wires or cables is transferred by bond resistance to the concrete, thus placing it in compression. This process is called pre-tensioning. In post-tensioning, the concrete is cast with properly located ducts for the reinforcement and after it has reached its specified compressive strength, the wires or cables are stretched by hydraulic jacks to the desired tension. Then end anchorages are attached and the jacks released, which transfers the stress to the concrete, placing it in compression. The remaining space in the ducts is filled with grout under pressure.

The process of prestressing takes advantage of the fact that concrete is strong in compression but weak in tension. Members are designed so the entire concrete section remains in compression when live loads are applied.

For buildings, prestressed concrete is best adapted for use where spans and panel dimensions are uniform, to take advantage of form reuse at the casting plant. Girders spanning 120 ft have been used. For roof and floor slabs and joists, spans vary greatly. Channel, tee and double tee sections, as well as flat and hollow slabs, are used for roofs and floors.

The big savings in cost of prestressed concrete construction result from efficient use of materials, mass production, and rapid erection. The high-strength concrete and high-tensile-strength steel are more expensive, but the quantities of both steel and concrete are greatly reduced in the prestressed design. For railroad use, prestressed concrete lends itself well to large warehouses and freight houses, and for floor and roof slabs on smaller buildings. It is highly fire resistant, and usually requires no additional finish.

b. Tilt-Up Slab Walls

Tilt-up slab walls are not really new, having been used as early as 1906–1912. New methods have been developed recently which, combined with better materials and new equipment, make this type of construction practical and efficient. Tilt-up slab construction has been used for multi-story buildings, but its most extensive use has been in one-story buildings for warehousing and industrial uses.

The concrete floor slab for the building is usually used as a bottom form, with wood or steel side forms. Openings where required are also formed. A liquid, such as curing compound or wax, is placed on the floor slab to prevent bond between the floor and wall panel. Reinforcing steel designed for load and lifting stresses is positioned and the concrete placed. After sufficient time is allowed for curing, the slab is tilted into place

and secured to its supporting columns which are usually of concrete and often precast. Pleasing exterior finishes may be developed in the troweling or by casting against form liners. Provisions for attaching interior insulation and wall finish may be made at the time the tilt-up slab is cast. Electrical conduit and outlets may also be placed before placing concrete.

This type of construction has the advantages of low cost and rapid erection, and requires little skilled labor. The exterior appearance is pleasing, and the building is highly fire resistant.

c. Lift-Slab Construction

The use of lift-slab construction has been developed to eliminate the building of and removal of forms for the concrete floor slabs. Floors are designed as flat slabs so that the surfaces of the slabs have no projections or dropped panels. The columns of the building are first erected on their foundations. The basement or ground floor is then cast and machine troweled to a smooth surface. Steel collars are placed around each column in number equal to the number of the floors in the building. These collars become an integral part of each floor slab as it is cast and provides for later anchorage to the columns by welding. The surface of the basement floor is coated with wax or some other bond-preventive material. All reinforcing and conduits are placed and the concrete cast and machine troweled. After the concrete has set properly, the procedure is repeated for each of the succeeding floors.

Columns usually are of steel, and additional length of columns are spliced on as needed to facilitate the lifting. Concrete columns have also been used. Hydraulic jacks are mounted on the tops of the columns and the lifting of the slabs begins. Electronic controls are used on the jacks to maintain uniform lifting of the slabs. Depending on the number of floors, a sequence plan for the various lifts of slabs and extension of columns is followed. When the slab has been lifted to its final position, it is anchored to the columns. Prestressing is often used in the design of lift slabs to minimize deflections. Lift-slab construction is used for multi-story buildings. Where floor areas are large, the slabs may be cast and lifted in sections.

Lift-slab construction cuts costs by eliminating expensive forming and the cost of hoisting concrete to upper floors. Also, rapid erection is a cost-saving factor. The added cost of lifting the slabs is much more than offset by these savings. The top and bottom surfaces of the slabs are smooth and may not require any further finish. This type consrtuction is highly fire-resistive.

d. Thin-Shell-Concrete Construction.

Thin-shell concrete construction is receiving more consideration each year. Up to the present, it has been used more in Europe and South America than in the United States. The design calculations for this type of structure have now been greatly simplified, which has increased its use in recent years.

Thin-shelled structures may be classified as long-barrel shells, short-barrel shells using arch ribs, domes, hyperbolic paraboloids, and folded-plate shells. The short-barrel shells are used to span large areas with floor space uninterrupted by columns. Spans of 300 ft are not unusual, with shorter spacing of the arch ribs varying considerably. Long-barrel shells are usually of multiple spans where the length of the cylindrical shell is greater than the radius of curvature, and the chord width. The cylindrical sections are usually circular and have stiffeners at the column lines and may or may not have edge beams at their lower edges. Variations in the shell design include double-curvature designs

using intersecting cylindrical surfaces, and domes of circular, elliptical, rectangular and polygonal forms. The hyperbolic paraboloid is a new development which is receiving favorable consideration on new projects.

The folded plate is a modification of the long-barrel shell in which the cylindrical shell is replaced by a shell of folded plane surfaces which intersect in a repetitive pattern. This type of construction gives rigidity to the thin shell and lends itself to cantilevered overhangs.

The thin concrete shells of any of the types listed above have the advantage of thin roof sections of lightweight, giving a relatively smooth undersurface which will take an attractive finish. The thin shell is remarkably durable. This durability was demonstrated in World War II when bombs perforated the shells and even destroyed supporting columns, yet the roofs remained standing. Damaged parts were removed and rebuilt repeatedly in some buildings which were bombed many times.

Forming of thin-shell structures is usually complicated, but structures are designed so that the forms can be reused repeatedly and are made readily moveable. Large savings in the cost of materials come from the thin concrete sections that are used. Prestressing has been used in some thin-shell structures, particularly in folded-plate designs.

Thin-shell concrete construction has many possibilities for use in railway structures: for shops, warehouses, piers, freight houses, large depots and terminal buildings. With the new simplified design procedures, its use will no doubt be expanded to provide many fire-resistive structures with floor space unobstructed by columns.

e. Precast Concrete

Precast concrete beams, joists, columns and rigid frames combined with precast floor and roof slabs and precast curtain-wall panels have been used successfully for large buildings in recent years. Mass production of units in a casting plant cuts costs in this type of construction by eliminating the costly building, tearing down and rebuilding of conventional wooden forms of columns, beams and slabs. The precast parts can thus be cast in advance and thoroughly cured before erection, and the finish obtained is superior to usual forming methods.

To simplify anchorage in the erection of the precast parts, steel plates or structural shapes are often cast into the tops of columns and the bearing areas of girders and beams. As the beams or girders are placed on the columns, they are then anchored in place by welding. In some cases, floors and roofs are supported on precast concrete joists, and the joists are used to support the forms for the floor or roof slab, which is then cast in place.

Channel or T sections or hollow slabs having widths of 1 to 2 ft and spanning up to 30 ft are the usual types used for floors and roofs. With the chemical and T sections a ribbed under-surface of pleasing appearance results, or if a flat under-surface is desired, a ceiling may be applied, and the channels used for recessed lighting, heating ducts and wiring.

Precast concrete curtain-wall panels are becoming more common and are usually constructed with a layer of insulation. A 5 in thick sandwich-type wall with 1½ in of insulation encased with 1¾ in of concrete, each side, and reinforced with wire mesh is equivalent to a 12-in brick wall in insulation value and strength and is much lighter in weight. Tongue-and-groove joints at the edges supplemented by filler strips and caulking provide weather tightness. The inner surface can be made smooth by casting this side against the form, and any desired exterior finish can be obtained by troweling, brushing or exposing the aggregates. Such panels can be cast in sizes to fit the framework of the

building and easily lifted by means of lifting loops cast in the concrete, and anchored to the framework by means of anchor clips or bolts. On several projects the cost in place of 5 in thick precast concrete curtain-wall panels has been about 60 percent of the cost of a 12-in brick curtain wall. Precast concrete construction should prove economical for small or large railway buildings, and such buildings are fire resistant and attactive in appearance.

f. Lightweight Concretes and Decorative Treatments

Within the past 10 years a wide range of materials known as lightweight aggregates has moved into prominence in the field of concrete construction. Savings of up to 30 percent in building dead load can be realized with lightweight aggregate concrete; and a greater reduction in total cost through possible subsidiary savings. Lightweight aggregates can be classified into the following five basic groups: (1) expanded shales, clays and slates; (2) expanded slags; (3) pumice; (4) perlite; and (5) vermiculite.

The aggregate materials are found in natural deposits or as by-products of the steel industry. With the application of intense heat they expand to many times their original size. A strong but light aggregate is thus formed to replace heavier materials in concrete. Lightweight concrete in a cured condition may vary in density from about 20 up to 100 lb per cu ft.

Expanded shale, slate, clay and slag concretes vary in weight from about 65 to 100 lb per cu ft. They are used for structural and insulation purposes, such as structural members, roof and floor fill and fire protection of steel. Pumice, perlite and vermiculite concretes weigh from about 20 to 85 lb per cu ft and are extensively used for insulation where structural strength is not required.

Cellular concretes have also moved into prominence in the building field during recent years. They are also referred to as aerated, gas, foam, or insulating concretes. Their low density is obtained by incorporating a homogeneous void or cell structure throughout the material. The voids may occupy from 25 to 75 percent of the concrete's volume. Unit weights range from less than 10 to more than 100 lb per cu ft.

The two most popular methods employed for making cellular concrete are the mechanical and chemical methods. The mechanical process involves high-speed mixing of cement, water and a foaming agent or a preformed air-foam. Foaming agents usually consist of hydrolyzed protein, rosin soaps, detergents or other organic agents. Fine aggregate, such as sand, is frequently used with the cement slurry.

In the chemical method, a reaction between the foaming agent and chemical compounds in the cement liberates gas which aerates the concrete. The most common gas-generating agent used in the chemical method is aluminum powder. Cellular concretes may have a wide range of physical properties. They are noted for their insulating qualities and are used for floor, roof and wall units.

Color and texture may be obtained in architectural concrete by using exposed decorative aggregates. Special facing aggregates are selected for their color and light reflectance. The most commonly used materials are quartz, marble, granite and ceramics. Aggregates are exposed by brushing away the retarded mortar in the face, by etching or by the aggregate-transfer method.

The aggregate-transfer method consists briefly of the following procedure: special aggregates are arranged and held in place on form liners by an adhesive; the liners are installed in the forms; concrete is placed and cured; and finally, forms are stripped and liners removed. Since the bond, of the aggregate is greater to the concrete than to the adhesive the aggregate "transfers" to the face of the concrete.

A wide range of surface textures can be obtained by additional surface finishing such as bush-hammering, grinding and wire-brushing. Exposed aggregate concrete is practicable for either small decorative areas or on all exposed surfaces of a building. It is economical because the expensive special aggregates are confined to a thin surface layer of concrete.

Concrete is used extensively in cast stone for lintels, sills, parapet coping, in fact any place where cut stone may be used. Concrete made with special aggregates and white portland cement may be cast in any shape required. It is attractive and durable, but considerably less expensive than natural stone. Color pigments or mineral dyes are available to provide permanently colored concretes which can be ground to highly polished surfaces.

The recent development of plastic and rubber form liners has opened new opportunities for producing attractive surfaces and patterns in precast concrete, cast-in-place concrete and concrete masonry. With plastic form liners an almost unlimited choice of three-dimensional designs can be cast into concrete with resulting surfaces as smooth as glass. Plastic liners can be reused many times, and no grinding, polishing or other finishing operation is required. Reusable plastic and rubber form liners have many possibilities for use in decorative wall panels, patterned panels, spandrel facings, columns, beams and other building components.

2. Brick and Concrete Block

a. "SCR" Brick

A new development in brick masonry is the "SCR" brick wall developed by the Structural Clay Products Research Foundation. This brick is a modular unit having nominal dimensions of 2⅔ by 6 by 12 in and is designed to be laid with ½ in mortar joints. Standard dimensions are 2 $\frac{5}{16}$ by 5½ by 11½ in. Each brick weighs 8 lb and is vertically cored by 10 holes each 1⅜ in. in diameter. A jamb slot is formed in the end of each brick ¾ in wide by ¾ in deep to facilitate installation of windows.

The "SCR" brick are designed to form a nominal 6-in wall with the face size being the same as that of standard "Norman" brick. They are laid in common half bond, with full bed and head mortar joints ½ in thick. The 6-in thickness makes it simple to turn corners and maintain the half bond without any supplemental corner unit. It is laid modularly with 3 courses to 8 in of wall height.

In laying the brick wall, special furring clips are placed in the mortar joints to allow for fastening 2- by 2-in furring strips on the inside of the wall. The furring strips provide space for any type of insulation and for fastening the inside wall finish, which may be plaster or dry-wall type. The furring space also keeps the inside finish dry.

This type of brick provides a rapidly laid masonry wall for one-story buildings, such as depots and freight houses, and is accepted by most building codes as a 6-in exterior masonry bearing wall. It has been found that masons can lay this type of wall more rapidly than a 4-in brick veneer wall. It should have many applications in small buildings for the railway industry.

b. Masonry Block

Concrete block masonry has become one of the leading types of masonry construction. It now accounts for three-quarters of the volume of all masonry walls being built. Concrete block have long been recognized as an excellent structural material, combining strength and economy with good appearance and fire resistance.

Concrete block are readily available in most localities and in many different shapes and sizes made with a variety of aggregates, such as sand and gravel, crushed stone and

slag in the heavy aggregates, and expanded slag, clay, or shale and volcanic or synthetic materials in the lightweight aggregates. The heavier aggregates provide higher strengths while the lighter ones are used to produce masonry block with better insulating and sound-absorption qualities.

It is easy to lay concrete block masonry units in a variety of distinctive patterns, such as stacked patterns, basketweave, and combinations of different size block, as well as common running bond. Unusual effects can also be obtained by offsetting block slightly in predetermined patterns to provide shadow effects. Special shadow block are also obtainable with three-dimensional designs cast in the block face. The new paints for use on concrete surfaces provide distinctive and attractive color schemes. Patterns and color are used both on interior and exterior walls. Where the appearance of rough stone is desired, split block may be obtained in a variety of colors and sizes.

The module for concrete masonry units is 4 in, and most block are made in multiples of this dimension, although block are also made in non-modular sizes for special purposes.

Recent developments in block manufacturing machines provide for production of many special block for specific purposes. Careful architectural planning of a building makes it possible to build without any cutting of block. Units are now obtainable in regular stretcher block, single- and double-corner units and half block, sill, lintel and door and window jamb block, pier and pilaster units, bullnose, solid top and various header and floor block. "U" section block of modular size are used to form lintels, with necessary steel reinforcing bars properly located and concrete placed as required to complete the lintel. Special jamb and sill block make the placing of any type of window sash or glass block a simple matter.

Concrete masonry block are usually referred to by their nominal sizes. An 8- by 8- by 16-in block measures 7⅝ by 7⅝ by 15⅝ in, and is laid with ⅜-in mortar joints to fill an 8- by 16-in space in the wall. Most concrete blocks are hollow with the core area being 40 to 50 percent of the total, and are manufactured to comply with building-code requirements or to certain specifications, such as those of the American Society for Testing Materials. These specifications cover required compressive strength and allowable absorption and moisture content of the block.

Building codes are usually quite specific as to height and thickness of exterior bearing walls and non-bearing partition walls. Exterior walls are usually 8 in or 12 in thick, and partition walls 4 in, 6 in and 8 in thick. Fire-resistance ratings depend upon wall thickness, the type of aggregate used in the block, and in some cases on whether or not the walls are plastered.

To provide stronger walls, as is necessary in some parts of the country because of siesmic code requirements, steel reinforcement may be added in the mortar joints or in the cores. Pilasters are also placed as needed to stiffen the walls.

Masonry block may be used in almost all types of railway buildings. They provide an economical fire-resistive structure that is pleasing in appearance and is strong and durable.

Report on Assignment 9

Architectural Requirements of Railway Buildings for Housing Electronic Data Processing Machines

G. J. Bleul (chairman, subcommittee), J. H. Adams, Jr., J. W. Hayes, J. D. Hubbard, W. C. Humphreys, A. A. Melius, J. B. Schaub, O. G. Wilbur.

Your committee submits the following report as information.

Electronic data-processing machines have been installed or are contemplated by a number of railroads to handle various accounting procedures in an efficient and economical manner. To properly house these machines in converted areas of a present building a detailed study and consideration of numerous architectural and structural problems are required. If a new building is to be constructed to house such equipment, these same considerations will generally apply.

Various requirements, such as space, location, floor loading, raised floor, air conditioning, heating, acoustical ceiling, partitions and power, are briefly discussed below to provide a guide for those who may have the responsibility to prepare a site for an electronic data-processing center.

Space and Location

The space required depends upon the data-processing system selected, provision for future expansion, areas for operating personnel, areas for maintenance equipment and personnel, tape storage areas and supporting equipment.

After the data-processing system has been selected and the requirements of the manufacturer have been made known, the site can be chosen. Generally, this location should be in close proximity to related work areas, such as those for key punch, sorting and tabulating equipment. Also, consideration should be given to the availability of power, present air conditioning, if it exists, and accessibility for moving the equipment to the desired areas.

Floor loadings require investigation. The size and weight of each manufacturer's equipment varies, and depending upon the allowable live load permitted in the areas selected, it may be necessary to strengthen the present floor.

Raised Floor

The electronic machines have a multitude of power and signal wires interconnecting them. In addition, there may be numerous air, vacuum, chilled or tower cooling water, steam and drain lines in the machine areas. To provide flexibility for the initial system and for future expansion, as well as accessibility and protection, a raised or false floor—under or around the machines—is usually recommended and frequently required, rather than troughs in the floor or overhead construction. However, in some installations it may be possible to run piping and wiring on the ceiling of the floor below, if the wiring is not too extensive.

A raised floor may be constructed of fire-retardant wood or metal designed for the particular installation, or an economical, manufactured, pedestal-type of floor may be used. These are made in a variety of types with adjustable-height pedestals and removable panels for access to the wiring and service lines. The required height of the false floor is approximately 7 to 9 in above the base floor, providing 4 to 6 in of clear space beneath, depending upon the requirements of the electronic machines.

Since dust control is vital for many of these machines, manufacturers usually recommend a rubber or vinyl tile as the floor covering to eliminate cracking or crumbling. The tile color should provide a contrast between the floor and the dust so that accumulations of dust and dirt would be readily apparent if the floor is not kept clean.

Air Conditioning

Air conditioning is necessary to dissipate the heat generated by the electronic machines. Also, the magnetic tapes used for recording of information, and certain machines, require a high degree of humidity and dust control. These requirements vary, depending on the data-processing system used, but generally, temperatures of approximately 75 F and humidity of approximately 40 to 60 percent are necessary on a year-around basis.

Where the installation is to be made in an area already air conditioned, it may be necessary to provide supplementary air conditioning to neutralize the heat from the equipment and control humidity. In areas without present air conditioning, installation of a central system is desirable because of the necessity for continuous operation, flexibility, heating and minimum maintenance.

In order to avoid costly shutdowns of a data-processing center due to possible air-conditioning failures, standby equipment is recommended. This equipment may be employed in the summer to provide comfort cooling to non-critical work areas related to the data-processing center. A service and maintenance contract should also receive serious consideration.

Some data-processing machines have integral built-in air conditioning units to dissipate the heat from their operation. It is necessary to provide tower cooling water and drain lines to these units in addition to the main system.

It is advisable to have a steam supply available for use throughout the year for humidity control. Also, this may be employed advantageously in conjunction with the air conditioning system for heating the data-processing center during the winter. If heating the area is not an integral part of the air conditioning, heating controls should allow operation of the data-processing center heating independent of the remainder of the building. Controls for the air conditioning may be electric, electronic or pneumatic, depending upon the critical nature of temperature and humidity.

For critical installations an alarm system is a desirable feature to warn operating personnel of a rise in temperature which, if allowed to continue unnoticed, may cause a costly interruption to the operation of the center.

Adequate dust control in the critical areas may be obtained by using commercial filters of a type that provides a greater degree of filtration than is usually required for comfort cooling. In this connection, sealing of the windows and the addition of storm windows may be required, or removal of the windows and complete closure of the openings may be a desirable alternative.

In tall buildings where costly rigging may be required for placing a water tank and tower on the roof, consideration should be given to the use of several smaller tanks and towers which can be readily disassembled. They may also provide greater flexibility of operation and added protection.

Acoustical Ceiling

A suspended, acoustical, metal-pan ceiling, backed with flameproof, paper-wrapped, sound-absorbing pads, is non-dusting and has good acoustical qualities. Recessed fluorescent lighting of normal office intensity is adequate and presents an attractive appearance. Minimum clear headroom should be approximately 8 ft 6 in.

The space above the suspended ceiling may be utilized as a return-air plenum as well as for the supply ducts of the air-conditioning system. This results in a saving of considerable duct work. In some installations the space beneath the raised floor has been used as a return-air plenum. If steam and water lines are also located above the suspended ceiling, they should be placed to avoid any possibility of leaks occurring over the electronic machines.

Partitions

Extensive partition work is usually necessary to provide the various rooms for the different component parts of the data-processing system, and for offices, maintenance, air-conditioning equipment, tape storage and "power central."

Partitions may be built of a variety of materials, depending upon building-code and insurance requirements. The desirability of acoustical treatment should be investigated. In some installations large windows have been placed in the partitions, separating the electronic machines from corridors, to permit viewing demonstrations of the operations by large groups of people.

In some localities, and depending on the type of construction, it may be necessary to incorporate a vapor barrier in the outside walls or exterior partitions of the air-conditioned data-processing center to prevent objectionable condensation.

Power

The area called "power central" contains the necessary motor-generator sets, transformer, power-control units and power-supply units for the electronic machines. In some systems air compressors and vacuum pumps are included. It is advantageous for this room to be located near the electronic machine areas to minimize the length of power cables and piping. However, in selecting the site, floor loading, vibration, noise and adequate ventilation require detailed study and consideration.

Effects of vibration on the building requires careful investigation. This can be minimized by the use of vibration eliminators and pads of adequate design, not only for many of the above items of equipment, but also for the compressors and pumps of the air-conditioning system.

It is recommended that air compressors, vacuum pumps, motor-generator sets and air-conditioning pumps and compressors be located so as to be remote from other occupied offices to avoid objectionable noise. A roof penthouse which has an intervening unoccupied or storage floor over offices, or a basement area, are preferable.

Planning an installation includes a survey of present electrical power and a determination of whether it is necessary to install a new power supply into the building to meet the requirements for the data-processing center, supporting equipment and air conditioning.

Fire Protection

The data-processing center should have a type of fire-protection equipment that would not cause damage to the electronic machines. Accidental water damage may require replacement of the machines, or unreliable readings could be obtained from tapes which have been water soaked. Manual extinguishers or automatic systems using carbon dioxide are recommended.

Miscellaneous

To aid in dust control, paint should be of a type that does not flake and chalk. Fabrics used in drapes or shades should be lint-free.

Other items to be considered in the planning of alterations include the availability of sufficient water at the proposed location of the air-conditioning equipment and adequate vertical service shafts for piping and wiring.

A study may be desirable to determine the necessity for treatment of the water to prevent or control the formation of scale and algae in the piping and water tanks.

An extensive communications system connecting the work, supporting equipment and electronic machine areas may be required.

Installation of a data-processing center requires close and continuous cooperation between the engineering, electrical, communications and accounting departments of the railroad, the electronic manufacturers and the various contractors for particular features of the project.

Report on Assignment 10

Consolidation of Buildings at Railway Terminals

F. D. Day (chairman, subcommittee), J. H. Adams, Jr., F. R. Bartlett, D. A. Bessey, H. M Booth, William Hayduk, J. F. Hendrickson, E. J. Hynes, B. J. Johnson, Jr., Earl Kimmell, S. E. Kvenberg, H. J. Lieser, W. H. Pahl, Jr., J. B. Schaub, H. T. Seal, E. R. Schultz, J. W. Westwood.

Your committee submits the following final report as information:

Consolidating various buildings at railway terminals is more important today than at any time in the history of the railroads, as they are faced with heavy competition from other forms of transportation and must make all possible economies both as to operation and maintenance in order to reduce expenses. To this end, the committee has explored what is being done on various railroads throughout the country to combine shop buildings, service buildings, freight and passenger station buildings and yard office buildings.

In view of the rapid consolidation of passenger operations into fewer and fewer wayside stations and their concentration primarily in large towns or cities, railway terminals are gradually coming to mean freight terminals. The local passenger traffic is being handled by buses on the highways or by private automobiles. The result of these practices, as far as passenger operation is concerned, has been to eliminate a great many of the small wayside stations. The clerical operation of the remaining stations has been consolidated into every second station or every fourth station or, in many cases, has been entirely abandoned as far as passenger business is concerned.

The freight clerical work is being transferred first into freight-passenger station combinations and ultimately into consolidated-area stations. This, of course, by eliminating the small wayside stations, pushes more business into the terminals. The volume of passenger cars handled through passenger terminals is gradually decreasing to the point where large coach yards are often little used other than for storing freight cars. Savings are possible in this situation by restricting the passenger car use of the yards to what is actually needed for passenger train operation and servicing, eliminating much of the stand-by passenger equipment and rearranging steam, air, water and power lines so as to reduce maintenance of facilities not used.

Where Pullman cars are serviced separately from a railroad's own equipment, savings again can be made by consolidating the Pullman and railroad cars into a single yard or, in some cases, on two or three specific tracks so that all operations on the cars are handled close to storeroom, locker room and welfare facilities. As passenger demand

decreases, stations in many cities can provide unused space to relocate terminal facilities and their personnel. The resulting shrinking of the passenger terminal to a centralized service area for passenger equipment and railroad personnel offers economies in the operation of the terminal.

Diesel engines are now handling all passenger trains in the country except in some electrified territory. Diesel engines, by and large, require less running maintenance and servicing than steam engines. This results in the rapid turn-around of diesel locomotives with resulting reduced lay-over time at the passenger terminals. Fewer roadside servicing facilities are required. Turntables are rapidly becoming obsolete. In most parts of the country, when they are required to lay over at the terminals, the diesel engines do not even require shelter overnight or weekends. This has resulted in relocating the enginehouse facilities into the passenger station itself. Where enough tracks are available, a separate track can be used for diesel inspection and minor running repairs. The enginehouse forces' welfare facilities in the medium size and smaller terminals can be combined with the yard coach and Pullman facilities. The engine-crew headquarters can be combined with the train-crew headquarters.

All railroads are aware of the economies to be realized from the consolidations outlined above. Many consolidations have taken place at large passenger terminals. The greatest economy generally results from combining welfare and locker facilities.

In freight terminals, the opportunity for combining various operations into fewer buildings is not as widespread as in the passenger terminals. Freight trains have been increased in length, resulting in a greater distance between the head end and rear end of the train, thus increasing the length required for classification and departure tracks and generally spreading the newer yards over a much larger area than formerly required. The result is, despite new construction, that the centralized buildings gradually acquire outlying buildings to accommodate train crews and yard personnel, thus defeating an effort to combine the buildings.

The clerical and yard work, of course, can be combined more effectively if use is made of modern communications, such as high-speed teleprinter, tape recording, video tape and remote radio communication or closed circuit TV. Some railroads have started automatic recording of defects on cars as they are received at the terminals with the thought that repairs can be programmed at a central location as the cars come to the location rather than putting all of the cars in a car repair yard and then taking the personnel and tools and material to the various cars.

The opportunity for consolidating the enginehouse facilities, now largely diesel, with the car shop facilities should not be overlooked at smaller terminals. While it is realized that different crafts are used for the two functions, a good start has been made by combining the supervision and storeroom personnel on some railroads. The engine and cars are normally all under a master mechanic who has charge of the full operation. With the rapid decline in enginehouse personnel brought about by the over 90 percent dieselization throughout the country, road and yard engines are no longer required to be at the enginehouse for as great a time as previously has been the case, nor do the railroads find it economical to attempt to service diesel engines at each yard and terminal. Diesel heavy repairs and even light repairs, including monthly inspections, are done at centralized, well-equipped shops. The result has been to reduce the enginehouse facilities to the bare minimum. Many abandoned roundhouses have been torn down, or have been leased, with all diesel servicing being done in the open at fueling stations where adequate fuel oil and sand is provided along with an inspection pit for running inspection. The oppor-

tunity to combine some of the enginehouse work with that of the car shop will result in combining the buildings necessary for the enginehouse people into a single facility that can house both car shop and enginehouse forces.

The railroads are on a threshold of a revolution in car shop repairs. Production-line methods are inevitable and will result, in a short time, in the necessity to construct a new type of car shop building that can handle cars on a production-line basis as they are passed through the various yards on the railroad's system. When these facilities are considered, they should not be looked upon as only car shop facilities. Any opportunity to put clerical forces, enginehouse forces, yardmasters and train crews into the building should be studied at the time any new car shop program is under way.

The result of all the consolidation, both in the passenger yards and freight yards, is that there is a tendency to utilize the existing buildings even though they may not be entirely adequate for the purpose. Many times an old building that was originally constructed as a car shop or enginehouse can be converted to a combined facility to house maintenance of equipment, yard crews and maintenance of way personnel. However, it should be remembered that many times the building is not in the ideal location where great savings could be made and that a little more study would result in a new building at a different location in the yard, one that would serve much better and save much loss of travel at the beginning and the ending of tours as well as at the lunch period.

The maintenance of way organization on various railroads has become more and more mechanized and streamlined. The result is that very few trackmen, carpenters or signal personnel are left at the terminals. If it is necessary that some be held at a terminal, then their headquarters should be combined with the other crafts insofar as welfare and toilet facilities are concerned. However, it should be kept in mind that it may be poor policy to put maintenance of way personnel into the middle of the yard if their work is on the main line. They may spend too much of their time attempting to get out of the yard. The mechanization of trackwork is being followed by mechanization of bridge and building work, and by gradual consolidation and mechanizing of the signal department. New machines and methods have required a different approach to maintenance in that department. This, in turn, results in different standards for shop repairs of signal equipment and for machinery repairs of both signal and track equipment. Many enginehouses or car shop buildings, now considered for abandonment, can be utilized at specific locations for repairs to maintenance of way machinery. As the volume of machines increases, the space to repair them is by necessity increased. Many shops that have been adequate are now found to be inadequate. New locations are being sought. A complete revision in policy is under way. When this occurs, combination of buildings should again be considered. If a centralized maintenance of way machinery repair shop is to be established, then the other work in the area should be surveyed also and a careful study made to see if, with a little more planning, the yard facilities could be combined into the machinery repair area.

As buildings are abandoned and work is combined, every effort should be made to lease or remove the abandoned buildings in order to save the fire risk, maintenance and taxing. If this is not done, there is a tendency gradually to spread out into the old buildings again, and much of the efficiency of consolidation is lost.

The consolidation of various buildings and their facilities in railway terminals is of timely importance, making possible economies in both operation and maintenance.

Report of Committee 20—Contract Forms

E. M. Hastings, Jr., *Chairman,*

D. F. Lyons, *Vice Chairman,*

A. F. Hughes, *Secretary,*

J. J. Baffa
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F. B. Mallas
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O. K. Morgan (E)
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J. L. Perrier
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C. M. Sherman
K. J. Silvey
W. R. Swatosh
J. W. Wallenius
D. J. White
D. H. Yazell
Clarence Young
H. L. Zouk

Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No revisions are offered for adoption this year, as the committee has begun a review of its entire chapter in the Manual, looking to bringing it up to date over the next two years.

2. Form of lease covering the use of railway tracks for storage of tank cars containing liquified petroleum gases, anhydrous ammonia, and other flammable or dangerous materials, collaborating with Fire Prevention and Insurance Section, AAR.

   Submitted for adoption and publication in the Manual ..... page 394

3. Form of lease covering right to strip-mine on railway miscellaneous physical property.

   Progress report, presented as information ..... page 397

4. Form of agreement to cover disposal of surplus railway property. In its initial study on this assignment, the committee found many complications which it decided to iron out before submitting a report for publication.

5. Form of agreement for unloading and storing liquified petroleum gases, anhydrous ammonia, and other flammable or dangerous materials, collaborating with Fire Prevention and Insurance Section AAR.

   Preliminary study revealed that this assignment is not worded in accordance with its scope. Therefore, your committee has requested that the assignment be reworded and will begin work thereon next year.

6. Form of agreement for construction and maintenance of highway–railway grade separation structures for public roads.
   Submitted for adoption and publication in the Manual ..... page 404
7. Bibliography on subjects pertaining to contract forms.
   Work has been started on this subject, a new one for this year, but the time has been too short to develop anything for publication.

THE COMMITTEE ON CONTRACT FORMS,
E. M. HASTINGS, JR., *Chairman.*

AREA Bulletin 553, November 1959.

Report on Assignment 2

Form of Lease Covering the Use of Railway Tracks for Storage of Tank Cars Containing Liquified Petroleum Gases, Anhydrous Ammonia, and Other Flammable or Dangerous Materials

Collaborating with Fire Prevention and Insurance Section, AAR

W. D. Kirkpatrick (chairman, subcommittee), G. H. Beasley, W. P. Coliton, R. F. Correll, Manuel Garcia, R. C. Heckel, A. F. Hughes, F. M. Jones, L. W. Lindberg, W. L. Mogle, J. L. Perrier, C. M. Sherman, K. J. Silvey, D. H. Yazell.

Last year, your committee presented as information a draft of an agreement to cover this subject (Proceedings Vol. 60, 1959, pages 304–307, incl.) and invited suggestions and criticisms thereon. This agreement has been reviewed and revised in accord with suggestions received, and is presented herewith for adoption and publication in the Manual at the end of Part 4, Agreements Covering Track, Chapter 20.

FORM OF LEASE COVERING THE USE OF RAILWAY TRACKS FOR STORAGE OF TANK CARS CONTAINING LIQUEFIED PETROLEUM GASES, ANHYDROUS AMMONIA AND OTHER FLAMMABLE OR DANGEROUS MATERIALS

THIS LEASE, made this ..... day of ..... 19..., by and between ....., a corporation organized and existing under the laws of the State of ....., hereinafter called the Railway Company and ....., hereinafter called Lessee.

WITNESSETH:

WHEREAS, the Railway Company owns certain tracks and appurtenant lands hereinafter called "premises" situated in the ....., County of ....., State of ..... further described as follows:

.....

.....

in accordance with plan ....., dated ....., designated as ....., hereto attached and made a part hereof, and

WHEREAS, the Lessee desires to lease said premises from the Railway Company for the purpose of storing tank cars owned or leased by Lessee containing ...., and

WHEREAS, the Railway Company is agreeable to granting to the Lessee a lease for such purpose;

NOW, THEREFORE, in consideration of a rental of ....., paid by the Lessee to the Railway Company, and of the covenants herein contained, the Railway Company hereby leases said premises to the Lessee subject to the following terms and conditions:

1. Purpose

The premises shall be used solely for storing tank cars owned or leased by Lessee containing .....

2. Service

Upon the terms and conditions of this agreement expressed, Lessee shall be served by Railway Company's locomotives and crews over the hereinbefore described premises.

3. Notice

Any written notice given by the Railway Company to Lessee shall be deemed to be properly served if the same be delivered to Lessee, or one of Lessee's agents, or if posted on the premises, or if mailed, postpaid, addressed to Lessee at Lessee's last known place of business.

4. Rent

Lessee shall pay to the Railway Company a rental of ..... per ....., payable ..... in advance, beginning ....., 19 ...

5. Refund

Rent paid in advance for a period extending beyond the termination of this lease shall be refunded to Lessee, unless such termination shall be on account of violation or non-fulfillment of any of the terms of this lease by the Lessee, or on account of abandonment of the premises by the Lessee, in which case the amount paid as rental shall be retained by the Railway Company.

6. Taxes and Charges

Lessee shall pay during the term of this lease all taxes, licenses and other charges which may be assessed or levied upon the premises, and upon the business of Lessee upon the premises, or against the Railway Company by reason of occupation or use of the premises.

7. Condition of Premises

Lessee shall at all times keep the premises in a safe, clean and sanitary condition, and shall not mutilate, damage, misuse, alter or permit waste thereon. The Railway Company reserves the right to inspect the premises.

8. Laws and Regulations

Lessee shall, with respect to any of Lessee's cars placed or stored on the premises which contain any flammable product or other products of a hazardous nature, comply with all applicable Federal, State or Municipal orders, regulations and ordinances, and with all orders, regulations and recommendations from time to time prescribed or pub-

lished by any public authority having jurisdiction, or by the Railway Company, relating to the type of cars and the contents thereof, or of any safeguard safety device, or procedure to be used in storing said cars on premises.

9. Liability

Lessee covenants and agrees to indemnify, protect and save the Railway Company harmless from and against any and all loss of or damage to any property whatsoever (including property of the parties hereto and of all other persons whomsoever), and any and all loss or damage on account of injury to or the death of any person whomsoever (including employees and patrons of the parties hereto and all other persons whomsoever), and from and against any and all suits, claims, liabilities or demands for such loss or damage, and any cost and expenses in connection therewith, caused by or growing out of the operations of this lease or the presence of said cars, or their contents, on the premises, whether caused by the fault, failure or negligence of the Railway Company, its agents, servants, employees or otherwise.

10. Insurance

Lessee at its cost and expense shall procure and during the continuance of this lease maintain in effect a policy of insurance acceptable to the Railway Company covering the Lessee's liability assumed under this agreement with limits of not less than $..... for the injury to or death of one person and not less than $..... for any one accident resulting in personal injury or death and not less than $..... for property damage for any one accident. The Railway Company shall be furnished with a certified copy of the policy which shall be endorsed to provide for thirty days written notice to the Railway Company prior to termination of the policy and before any changes are made therein. The furnishing of insurance shall not be deemed a limitation on the liability of Lessee as provided in this agreement but shall be additional security therefor.

11. Term

This lease shall be effective ....., 19..., and shall extend to ....., 19..., unless sooner terminated, as hereinafter provided.

12. Termination

Either party hereto may terminate this lease at any time, by giving to the other party ..... days written notice to this effect as herein provided. Acceptance of rent in advance by the Railway Company shall not act as a waiver of the right to terminate this lease.

13. Abandonment

The failure of Lessee to occupy or use the premises for the purpose herein mentioned for ..... days at any time shall be deemed an abandonment thereof. An abandonment of the premises by Lessee shall, at the option of the Railway Company, operate as an absolute and immediate termination of this lease without notice.

14. Forfeiture

Any breach of any covenant, stipulation or condition herein contained to be kept and performed by Lessee, shall be sufficient cause for the immediate termination of this lease.

15. Insolvency or Bankruptcy

If Lessee at any time during the continuance of this agreement should become insolvent or bankrupt, or if Lessee's affairs should be placed in the hands of a receiver, this lease shall, at the option of the Railway Company, terminate.

16. Renewal

A lawful continuance of the tenancy beyond said term shall be deemed a renewal thereof for the further term of ..... to end at the expiration thereof, without further notice; and every further lawful continuance shall be deemed a further renewal for a like term, to end in like manner, and every renewal or holding over shall be subject to the provisions of this lease.

17. Assignment

This lease shall not be assigned or in any manner transferred, nor shall said premises or any part thereof be sublet, used or occupied by any party other than the Lessee, nor for any purpose other than that specified herein, without written consent of the Railway Company.

18. Successors

Until terminated as hereinbefore provided, this lease shall inure to the benefit of and be binding upon the parties hereto, their heirs, executors, administrators, successors, and assigns.

In Witness Whereof, the parties hereto executed this lease in .....
....., as of the day and year first above written.

.....Company

Witness: ..... By: .....

.....Lessee

Witness: ..... By: .....

Report on Assignment 3

Form of Lease Covering Right to Strip-Mine on Railway Miscellaneous Physical Property

D. F. Lyons (chairman, subcommittee), J. J. Baffa, G. H. Beasley, W. P. Coliton, R. F. Correll, G. K. Davis, C. R. DuBose, A. F. Hughes, F. M. Jones, F. B. Mallas, E. E. Phipps, D. H. Yazell, H. L. Zouck.

Your committee submits, as a progress report and for information, a draft of the above-named form.

In most of the locations where strip-mining is feasible, the railroad undoubtedly, has title to both the land surface and the underlying minerals. The situation may occur, however, where the railroad may own the surface rights but not the mineral rights, and vice versa. As your committee understands its assignment, the form is to be worded to cover the case where the railroad owns the surface rights and may or may not own the mineral rights.

Your comments are invited not only on the draft herewith presented but also on the advisability of changing the assignment or perhaps adding an assignment to cover the case where the railroad owns the mineral rights only.

Acknowledgments

The committee wishes to acknowledge the helpful suggestions and assistance of Walter B. Roe, geologist for a coal mining concern, J. C. Kenady, land and tax commissioner of the Great Northern Railway, H. S. Loeffler, assistant chief engineer of the Great Northern, W. R. Bjorklund, district engineer of the Northern Pacific Railway, and S. J. Owens, general manager of The Minneapolis & St. Louis Railway.

FORM OF LEASE COVERING RIGHT TO STRIP-MINE ON RAILWAY MISCELLANEOUS PHYSICAL PROPERTY

THIS LEASE, made this ..... day of ....., 19..., by and between ....., a corporation organized and existing under the laws of the State of ....., hereinafter called the Railway Company, and ....., hereinafter called the Lessee.

WITNESSETH:

WHEREAS, the Railway Company owns certain premises situated in ..... County of ....., State of ....., further described as follows ..... and as shown on map entitled "....."., dated ...., hereto attached and made part hereof, and

WHEREAS, the Lessee desires the right and privilege to mine and remove the ...*... on or underlying the surface of said premises, and

WHEREAS, the Railway Company is agreeable to granting the Lessee a lease for such purposes;

NOW, THEREFORE, in consideration of $..... cash in hand paid by the Lessee to the Railway Company, of the royalties hereinafter provided, and of the covenants herein contained, the Railway Company hereby grants said lease, subject to the following terms and conditions:

1. Mining Rights

The Railway Company insofar as it lawfully may, grants to the Lessee the privileges to mine by the strip-mining method and to remove the .....*..... found on or under the tracts or parcels of land above described, except as hereinafter provided, together with the right of ingress and egress and with such other rights as may be customary or necessary for the proper conducting of strip-mining operations upon the land above described, except that if by reason of the provisions contained in any of the deeds and conveyances for the respective tracts of lands herein leased Lessee has no right to mine .....*..... upon the said lands, additional mining rights shall be obtained by Lessee at its own cost and expense.

2. Timber Rights

The Railway Company reserves the right to remove from the leased premises such timber as it may elect.

3. Term

This lease shall be effective ..... (date) and shall extend for a period of ..... years. It may be renewed for a ..... period, upon the same conditions, upon six month's notice by the Lessee prior to the date of expiration.

4. Exceptions and Reservations

The Railway Company reserves the rights for existing railroad facilities and leases within the area described, and further reserves the right to construct, operate and maintain additional railroad facilities and grant leases that do not interfere with the mining privileges.

5. Depth of Strip-Mining

The Lessee shall mine by strip-mining all of the merchantable .....*..... on or underlying said tracts or parcels of land where the cover overlying the ..... seam or vein of ..... is not more than ..... feet in depth.

6. Disposal of Screenings

In the event the Lessee conducts screening operations on the above-described premises, the residue material shall be disposed of by the Lessee in a manner satisfactory to the Railway Company.

7. Deep Mining

The Lessee shall conduct strip-mining operations in such a manner as not to hinder or interfere with the mining of the remainder of the ..... underlying the tracts or parcels of land described above by deep mining. The Lessee shall leave the face of the .....*..... exposed at such points as designated by the Railway Company for deep-mine openings and the Lessee shall also grade drainways and openings as designated by the Railway Company across the spoil pile for drainage from the deep-mine openings and for other purposes.

8. Minerals Discovered

The Lessee shall occupy and hold for the Railway Company all cross or parallel lodes, dips, spurs, feeders, crevices or mineral deposits of any kind other than ....*.... which may be discovered and shall immediately notify the Railway Company of such discovery.

9. Auger-Mining

The Railway Company hereby further grants to the Lessee the right and privilege to auger-mine the leased premises, but before commencing said auger-mining operation, Lessee shall submit a plan thereof to the Railway Company for its approval in writing.

10. Method of Mining

The Lessee shall mine and remove the .....*..... in an efficient, workmanlike, practical and proper manner, in conformity with approved and modern strip-mining methods, and all local, State, or Federal applicable laws and regulations.

11. Grade Crossings

The Lessee may construct and maintain such grade crossings as may be approved by the Railway Company and shall provide such crossing protection as may be declared necessary by the Railway Company.

12. Liability

Lessee covenants and agree to indemnify, protect and save the Railway Company harmless from and against any and all loss of or damage to any property whatsoever (including property of the parties hereto and of all other persons whomsoever), and any

and all loss or damage on account of injury to or the death of any person whomsoever (including employees and patrons of the parties hereto and all other persons whomsoever), and from and against any and all suits, claims, liabilities or demands for such loss or damage, and any cost and expenses in connection therewith, caused by or growing out of the operations of this lease or the operations of the Lessee hereunder, whether caused by the fault, failure or negligence of the Railway Company, its agents, servants, employees or otherwise.

13. Insurance

Lessee at its cost and expense shall procure and during the continuance of this lease maintain in effect a policy of insurance acceptable to the Railway Company covering the Lessee's liability assumed under this agreement with limits of not less than $..... for the injury to or death of one person and not less than $..... for any one accident resulting in personal injury or death and not less than $..... for property damage for any one accident. The Railway Company shall be furnished with a certified copy of the policy which shall be endorsed to provide for thirty days written notice to the Railway Company prior to termination of the policy and before any changes are made therein. The furnishing of insurance shall not be deemed a limitation on the liability of Lessee as provided in this agreement but shall be additional security therefor.

14. Term

This lease shall be effective ..... (date) and shall extend for a period of ..... years. It may be renewed for a ..... period, under the same conditions, upon six months' notice by the Lessee prior to the date of expiration.

15. Exceptions and Reservations

The Railway Company reserves the rights for existing railroad facilities and leases within the area described, and further reserves the right to construct, operate and maintain additional railroad facilities and grant leases that do not interfere with the mining privileges.

16. Rentals and Royalties

The Lessee shall pay to the Railway Company a rental or royalty of ...., payment to be made monthly not later than the ..... day of each month for the .....*..... shipped during the preceding month; provided, however, that for the year beginning January 1, 19..., and every year thereafter, the Lessee shall pay to the Railway Company a minimum rental or royalty of $....., such minimum payment to be made not later than the ..... of the succeeding year.

17. Taxes

The Lessee shall pay all taxes which may be levied or assessed upon the leasehold estate hereby created, the surface land used by the Lessee and all buildings and improvements placed thereon by the Lessee, for each year during the continuance of the lease, and all taxes that may be imposed upon the .....*..... after it is mined from said leased premises, or other products made from the .....*..... whether the taxes are so levied or assessed in the name of the Railway Company or the Lessee. If the Lessee fails to pay the taxes, or any part thereof, when and as they become due and payable, they may be paid by the Railway Company, and the Lessee shall pay to the Railway Company any such sums paid by the Railway Company within .....

days after demand therefor, with interest at the rate of ..... percent per annum, and the Railway Company shall have the same liens and remedies for the collection of money so paid by it as are hereinafter provided for and reserved to it for the collection of rentals or royalties.

18. Weight of Material Mined

The quantity of .....*..... mined from said leased premises and shipped in railway cars shall be determined by the weight sheets furnished by the Railway Company over which the .....*..... is shipped. Weight certificates from a licensed weighing station shall be furnished for all .....*..... shipped from the premises by any other means.

19. Records of Lessee

The Lessee shall keep an accurate record of all .....*..... mined and removed or converted into other products or used or stored on the leased premises, and a record of all analyses made or caused to be made by the Lessee of the .....*..... The authorized representatives of the Railway Company shall have access at any and all reasonable times to all such records for the purpose of inspecting, auditing and making copies of records. The Lessee shall, on or before the ..... day of each calendar month, furnish to the Railway Company a report in writing, showing the total quantity mined from the premises during the preceding month, under this lease.

20. Plan For Mine Development

The Lessee shall, before commencing any operations on the leased premises, submit to the Railway Company for approval a plan providing for the removal of the .....*..... Approval of the plan shall not constitute assumption of any liability by the Railway Company.

21. Inspection of Mine

The authorized representatives of the Railway Company shall have the right at all times to enter the workings and other operations of the Lessee under this lease in order to make inspections and surveys. The Railway Company may direct the Lessee, by notice in writing delivered to the mine superintendent or any other person in authority at the mine on the leased premises, to stop or remedy immediately any mining practices or other acts which may in its opinion cause any loss or injury, and the Lessee shall comply with such direction.

22. Removal of Property after Term

When this lease shall terminate by reason of the Lessee having mined all of the .....*..... and paid to the Railway Company all the royalties, rentals and other moneys required to be paid hereunder, and complied with all the covenants and agreements contained herein on the part of the Lessee to be kept and performed, then the Lessee shall within the period of ..... months from the date of termination, remove the mine plant, improvements, machinery and equipment which it has placed upon the leased premises. Any property not so removed by the Lessee within this period of ..... months shall become the property of the Railway Company, and it may remove the mining plant, improvements, machinery and equipment at the expense of the Lessee.

23. Assignment

The Lessee shall not assign, sublet or underlet, mortgage or convey this lease or the leasehold estate, rights or privileges hereby demised, or any part thereof or interest

therein, without first having obtained the written consent of the Railway Company. Any transfer by process of law or proceeding in equity, or any transfer of a controlling interest in the share of stock of Lessee to persons not now in control of Lessee, shall be deemed an assignment within the meaning of this provision and violation of this covenant. Subject to the provisions herein contained regarding assignment, this agreement shall extend to and bind the successors and assigns of the respective parties hereto.

24. Termination

The Railway Company shall have the right to terminate this lease if the Lessee shall default in the payment of rentals, royalties or any other money herein provided to be paid by the Lessee when and as due and payable, or if the Lessee shall fail to keep, observe or perform any of the covenants, agreements or conditions in this lease, and if any such defaults shall continue for a period of ..... days after written notice is given by the Railway Company to the Lessee.

The Railway Company shall also have the right to terminate this lease if the Lessee shall make any assignment for the benefit of creditors, or shall be adjudicated bankrupt, or file an application under ..... of the Bankruptcy Act or any amendment thereto or substitute therefor, or any answer admitting material allegations of an application filed against Lessee thereunder, or shall suffer or permit a receivership of the Lessee's property. No demand for the payment of rentals or royalties or other money required to be paid by the Lessee, nor other notice of default than above provided, nor any re-entry by the Railway Company shall be necessary in order to effect a termination of this lease. The Railway Company may thereupon or at any time thereafter, without further notice, demand or action, re-enter and take possession of the leased premises, or any part thereof, to the same extent and with like effect as though this lease had never been made. In case the Railway Company exercises the right herein provided to declare this lease terminated, it shall not be liable to the Lessee for any injury or damage by reason thereof, and the Lessee hereby expressly waives and releases any and every claim for any such injury or damage. But the exercise by the Railway Company of the right to declare this lease terminated shall not be held to release or impair any then-existing obligations or liability of the Lessee hereunder or any right or remedy herein granted to or in any manner vested in the Railway Company or otherwise available to it for the collection of rentals, royalties or other money payable hereunder or the enforcement of any other liability.

25. Railway Company's Liens

In order to secure the payment of all rentals or royalties and other moneys herein provided to be paid by the Lessee, the Railway Company is hereby given a first lien upon the leasehold estate hereby created and upon all houses, buildings, structures, ovens, rails, railroad tracks, equipment, machinery, improvements and property of every kind and character which may be placed by the Lessee upon the leased premises.

26. Railway Company's Rights Not Waived

No delay or omission of the Railway Company to exercise any right, remedy or lien accruing upon any default or forfeiture hereunder, or otherwise available to it, shall impair, prejudice or waive any such right, remedy, or lien, but every such right, remedy and lien may be exercised by the Railway Company in the same manner and to the same extent as if such delay or omission had not occurred.

27. Arbitration

Disagreements or disputes between the Railway Company and the Lessee as to any of the covenants, agreements or conditions of this lease, or as to the performance or non-performance thereof, that cannot be settled between the parties hereto shall be settled by a sole, disinterested arbitrator within ..... days after demand for arbitration is made by either party hereto; such arbitrator shall be appointed by the judge of the ..... Court of ..... The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as determined by the arbitrator.

28. Notice to Lessee

The giving of any notice to the Lessee under the provisions hereof, the manner of which is not otherwise herein expressly provided, shall be sufficient if in writing, and one copy thereof, addressed to the Lessee, is left with the superintendent, manager or an agent in charge of the mines or of the mine office of the Lessee, and one copy thereof is sent by registered mail to the Lessee at its last address furnished the Railway Company. If there shall be no one found in charge of the mines or of the mine office of the Lessee, then one copy of the notice shall be posted on the front door of the mine office or at the entrance to the mine.

29. Notice to Railway Company

The giving of any notice to the Railway Company under the provisions of this lease shall be sufficient if in writing and sent by registered mail to the Chief Engineer of the Railway Company at .....
All plans, maps, reports and other records and information herein required to be furnished by the Lessee to the Railway Company shall be mailed to the Chief Engineer of the Railway Company at the above address, unless and until the Lessee shall be otherwise instructed in writing by the Railway Company.

30. Modifications

No waiver, release, modification, alteration or amendment of any of the terms, conditions or provisions of this lease shall be valid or set up or relied upon or offered in any judicial proceeding or otherwise unless the same is in writing, duly executed by the Railway Company and the Lessee.

In Witness Whereof, the parties hereto have executed this instrument in .....
....., as of the day and year first above written.

Attest: ....Company
Secretary By: .....

Attest: ....Lessee
Secretary By: .....

Note.—Insert the name of the material to be mined in all blanks marked ....*

Report on Assignment 6

Form of Agreement for Construction and Maintenance of Highway–Railway Grade Separation Structures for Public Roads

J. L. Perrier (chairman, subcommittee), A. F. Hughes, H. F. Brockett, G. K. Davis, C. R. DuBose, Manuel Garcia, J. F. Halpin, R. C. Heckel, F. M. Jones, F. B. Mallas, W. J. Malone, F. J. McMahan, W. I. Mogle, C. M. Sherman, K. J. Silvey, W. R. Swatosh, J. W. Wallenius, Clarence Young.

Last year your committee submitted as information a draft of Form of Agreement for Construction and Maintenance of Highway–Railway Grade Separation Structures for Public Roads (Proceedings, Vol. 60, 1959, pages 308 to 314, incl.) and invited comments and criticisms thereon. This form of agreement is now submitted with the recommendation that it be adopted and published in the Manual at the end of Part 7, Miscellaneous Agreements, Chapter 20, with the following revision:

In the next-to-last sentence of Sec. 9. Future Maintenance of Facilities, change the word "reasonable" to ".....days."

Report of Committee 3—Ties

F. J. Fudge, *Chairman,*

W. E. Fuhr, *Vice Chairman,*
R. S. Belcher (E)

A. C. Black
P. D. Brentlinger
R. G. Brohaugh
C. S. Burt
W. J. Burton (E)
G. B. Campbell
C. J. Code
E. L. Collette
L. C. Collister
R. W. Cook
L. P. Drew
H. R. Duncan
T. H. Friedlin (E)
A. K. Frost
H. E. Grier
F. F. Hornig
B. D. Howe*
M. J. Hubbard
R. P. Hughes
C. E. Jackman
W. R. Jacobson
H. W. Jensen
W. L. Kahler
H. F. Kanute
L. W. Kistler
W. E. Laird
C. M. Long
J. W. Neikirk
R. B. Newbery
H. B. Orr
R. W. Orr
C. A. Peebles
R. R. Poux
R. B. Radkey
W. C. Reichow
N. B. Roberts
H. S. Ross
N. A. Salzano
C. V. Schutt
R. B. Smith
E. F. Snyder
L. S. Strohl
S. Thorvaldson
G. A. Williams

Committee

(E) Member Emeritus.
* Died July 20, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report including recommended revisions ..... page 407

2. Extent of adherence to specifications.
   Progress report, presented as information ..... page 407

3. Substitutes for wood ties.
   Progress report, presented as information ..... page 408

4. Tie renewals and costs per mile of maintained track.
   The report on this assignment, consisting of the annual statistics compiled by the Bureau of Railway Economics, AAR, and providing information about tie renewals and cost data for 1958, was published in Bulletin 551, June–July 1959.

5. Methods of retarding the mechanical wear of ties, including stabilization of wood, and the splitting of cross and switch ties, collaborating with Committee 5.
   Progress report, presented as information ..... page 412

6. Bituminous coating of ties for protection from the elements.
   A questionnaire was sent to 28 railroads requesting information on any bituminous tie coating installations. Summary of this information will be presented next year.

THE COMMITTEE ON TIES,
F. J. FUDGE, *Chairman.*

AREA Bulletin 554, December 1959.

MEMOIR

Ben David Howe

Ben David Howe, chief lumber inspector of the Louisville & Nashville Railroad, died suddenly in Montreat, N. C., on July 20, 1959, following a heart attack which occurred while he and Mrs. Howe were vacationing on the beach at Montreat. He is survived by his wife, Mrs. Maybelle Wheeler Howe, two daughters, one son, and three grandchildren.

Mr. Howe was born on September 5, 1893, at Elizaville, Ky. He was graduated from the University of Kentucky as a civil engineer in 1916 and entered the service of the Louisville & Nashville as a draftsman on July 30 of that year.

Mr. Howe joined the American Railway Engineering Association on June 5, 1933. He became a member of Committee 17—Wood Preservation, in 1942. He was also a member of Committee 3—Ties, and gave capable leadership to that important committee as its chairman during the period from April 1949 to March 1952. He gave valued service to Committee 5—Forest Products, of the Association of American Railroads from 1956 through 1959. He was a member of the American Wood Preservers' Association for many years and served as president of that organization in 1955.

Mr. Howe was a diligent worker on all the committees with which he served and evidenced more than usual interest in all committee affairs. In addition to his capacity for work, he had an attractive and pleasing personality and a keen sense of humor. Truly, it can be said he lived a full and useful life, devoted to his family, his church, and his work.

Mr. Howe had a great capacity for friendship. He leaves a host of friends, particularly throughout the railroad and wood-preserving industries who are well acquainted with the sterling qualities which made his friendship so pleasant at all times. His sound knowledge, judgment, counsel, and genial ways be greatly missed during the years ahead.

CLARENCE BURT, *Chairman*
ROBERT B. RADKEY
H. R. DUNCAN
Committee on Memoir

Report on Assignment 1

Revision of Manual

W. E. Fuhr (chairman, subcommittee), P. D. Brentlinger, G. B. Campbell, E. L. Collette, L. P. Drew, H. R. Duncan, B. D. Howe, W. R. Jacobson, W. L. Kahler, L. W. Kistler, R. B. Radkey, N. A. Salzano, E. F. Snyder, W. J. Burton.

Your committee submits the following recommendations with respect to Chapter 3 of the Manual:

Page 3–1–6

MARKING TIES TO INDICATE SIZE ACCEPTANCE

Reapprove without change.

Page 3–1–8

SIZE OF HOLES BORED FOR SPIKES

Reapprove without change.

Pages 3–1–9 and 3–1–10

SPECIFICATIONS FOR TIE PLUGS

Reapprove without change.

Pages 3–1–11 and 3–1–12

SPECIFICATIONS FOR DATING NAILS

Reapprove without change.

Pages 3–1–14 to 3–1–16, incl.

SPECIFICATIONS FOR TIE COATINGS, THEIR APPLICATION AND TESTS

Reapprove without change.

As information, your committee calls attention to a recently developed machine that drives straight-sided tie plus, i.e., it does not require the plugs to be pointed, as shown in the AREA Specifications for Tie Plugs. So there is a current interest in changing the design of tie plugs.

Report on Assignment 2

Extent of Adherence to Specifications

P. D. Brentlinger (chairman, subcommittee), C. S. Burt, H. R. Duncan, A. K. Frost, F. J. Fudge, F. F. Hornig, R. P. Hughes, C. E. Jackman, H. F. Kanute, L. W. Kistler, J. W. Neikirk, N. B. Roberts, H. S. Ross, N. A. Salzano, R. B. Smith, G. A. Williams.

The following report is submitted as information.

During the summer of 1959 Committee 3 inspected cross ties stored at two different treating plants in Georgia and North Carolina.

At the time the trip was made the railroads had just resumed the purchase of

cross ties and stocks were low at the plants. The ties observed were of oak, gum, and mixed hardwood from producing areas in Alabama, Georgia, North and South Carolina.

Incising of ties is done by the plants inspected, plus selective dowelling after seasoning. The railroads involved all use their own system of marking ties, and in general, acceptance was within reasonable tolerances. It was noted that the non-acceptance of Size 3a ties resulted in some 7-in-thick ties with 7-in faces being branded Size 4. The greatest variation in sizing occurred in the 6-in ties; too many were oversized.

Good housekeeping and general cleanliness at the plants were observed.

The members observed the controlled air seasoning process at the Atlanta plant, and were given an explanation of how it dries lumber, poles and ties.

A third plant was visited but no cross ties were handled there, only yellow pine timbers and poles. The committee observed these items in storage, going through the mill to trams, and in treated storage.

Report on Assignment 3

Substitutes for Wood Ties

M. J. Hubbard (chairman, subcommittee), C. J. Code, L. P. Drew, H. W. Jensen, W. E. Laird, C. M. Long, R. R. Newbery, H. B. Orr, C. V. Schutt, L. S. Strohl, S. Thorvaldson.

This is a progress report on substitutes for wood ties, which includes information on ties used in European countries, progress in prestressed concrete railroad ties (abstracted from Concrete Products, issues of April, May, and July 1958), and the work being carried out at the Association of American Railroads' Research Center.

Introduction

The fundamentals to consider in the designs of substitute ties as published in Chapter 3 of the AREA Manual, pages 3–5–1 and 3–5–2, have not changed. They are: fastenings, gage, line, surface, insulation and cause of failure.

During the period of railroad expansion, 1910 to 1925, prior to the development of our present wood treating processes, a number of patents were issued for various substitutes for wood cross ties of which several millions of the best types were installed in test sections on various railroads. A summary of the results of these tests was published in the Proceedings in 1953. This report brought out the fact that of all the substitute ties tested, none were of sufficient merit to be continued in service. Many of the steel ties which were installed in plant trackage of the major steel companies were removed account of corrosion and replaced with pressure-treated wood cross ties.

Installations in European Countries

The following data are taken from the 1954 report of Robert Levi, head of the Permanent Way Department, French National Railways.

In 1954, of a total of 120 million sleepers (cross ties) in service on the French Railways, 6 million were metal and 2 million reinforced concrete. Tie renewals in France are generally made at the time track is renewed, which includes renewal of rail, ties, ballast and track fittings in order to take advantage of the high output of mechanized equipment. In the interval between general renewals, maintenance gangs strive to prolong the life of sleepers as much as possible by such methods as cooperage of the ends

of wooden sleepers so as to combat splitting, the effect of which would be to relax the grip of the wood on the threads of the coach screws (screw spikes); remaking of the base-plate bed which supports the rails and recutting of shoulderings; the introduction of extra material into the holes in sleepers in which the coach screws have worked loose; and replacing old sleepers here and there which have worn out, particularly on secondary lines where rail replacement is infrequent.

Fig. 1 shows welded rail on wood sleepers with double flexible fastenings, clips, rubber sole pads, steel base plates, and 46 kg U 33 rails (approximately 100 lb in U. S.)

Fig. 1.

Companies in France have for a long time experimented with two other materials as substitutes for wood sleepers: metal and reinforced concrete. It was found that metal sleepers gave good results on lines carrying a comparatively light traffic but could not be used on high-speed and circuited tracks. Life of wood sleepers in France is 25 to 35 years.

Fig. 2 shows welded rail on reinforced concrete sleepers.

The French Railways experienced difficulties with reinforced concrete sleepers in rail fastenings and joint conditions. Prestressed concrete sleepers were first used on French Railways in 1950, but no large-scale installations were made until about 1953.

Fig. 2.

A comparison of the cost of wood ties vs. prestressed concrete ties is given in the following tabulation, which shows the cost of sleepers in France in 1954, including purchase price (including all manufacturing, transportation, warehousing and subsidiary costs); the cost of rail fastenings; and the cost of installation and maintenance.

1. Hardwood sleepers, without base plate and with standard attachments ...$ 8.20 each
2. Hardwood sleepers with base plate and standard attachments .....$ 9.20 each
3. Hardwood sleepers with flexible attachments .....$ 9.63 each
4. Reinforced concrete sleepers with flexible attachments .....$10.94 each
5. Metal sleepers without base plate .....$11.49 each
6. Prestressed concrete sleepers with flexible attachments $14.57

The conclusion drawn from the experience of the French Railways is that the use of concrete sleepers could be regarded as a method of supplementing or regularizing the supplies of hardwood sleepers, even though it would be somewhat costly. But it presents certain advantages, as the concrete ties are reported to have a service life of 30 to 40 years.

Additional information on the design and production of prestressed concrete ties in France, Germany, Belgium and England may be found in Concrete Products, issues of April, May and July 1958, from which it may be noted that the cost per tie among these countries varies from $8 to $11, exclusive of hardware.

AAR Research Developments

The AAR Research Laboratory, after a thorough study of European designs of prestressed concrete ties, has produced such ties of three different designs: "A", "B", and "C", using both standard and lightweight aggregates.

The Design "A" ties are each 8 in high, 9 in wide and 8½ ft long, with slightly beveled edges. They weigh 600 lb each.

The Designs "B" and "C" ties are of the same length and width as the "A" tie, but are 1 and 2 in lower, respectively. The Design "C" tie weighs 300 lb.

Timber ties weigh from 150 to 200 lb each.

After thorough laboratory tests, the AAR research staff designed two other types: Designs "D" and "E", with 12-in base width and 6 and 7 in thick, respectively, to be spaced in track on approximate 27-in centers or about 16 ties per 39-ft rail length. These ties were designed for a bending moment of 150,000 in-lb at the center line of rail. The first ties were made of lime-rock aggregate and were not strong enough to sustain the loads that would be imposed on them in heavy-duty track. The same designs of ties are to be made with granite aggregate for further tests.

A number of rail fastenings have been tried for concrete ties, and it seems that bolts extending completely through the tie, with rail clips, have proven to be the most satisfactory.

Fig. 3 shows a typical bolt and rail-clip fastening.

Some of the latest information may be found in the September–October issue of Railway Materials and Equipment, in an article by G. M. Magee, director of engineering, research, AAR, entitled "The Story of Concrete Ties."

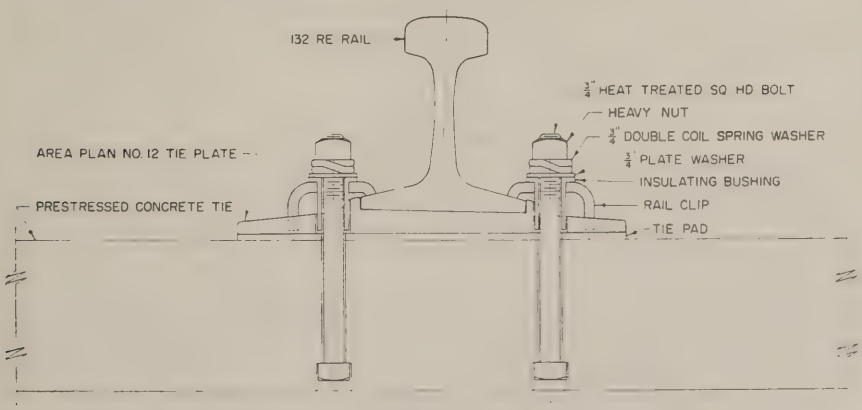


Fig. 3.

Conclusion

It is hoped that in the near future test installations of prestressed concrete ties can be made in track in order that data from actual service may be had to compare the durability, maintenance advantages and economies of such ties with treated wood ties. Research on this subject should be kept active, as there may be developed in the near future a substitute for wood ties that will be economically justified.

Report on Assignment 5

Methods of Retarding the Mechanical Wear of Ties, Including Stabilization of Wood, and the Splitting of Cross and Switch Ties

Collaborating with Committee 5

P. D. Brentlinger (chairman, subcommittee), R. S. Belcher, A. C. Black, R. G. Brohaugh, C. S. Burt, W. J. Burton, G. B. Campbell, C. J. Code, L. C. Collister, T. H. Friedlin, A. K. Frost, W. E. Fuhr, H. E. Grier, F. F. Hornig, B. D. Howe, C. E. Jackman, W. R. Jacobson, H. F. Kanute, R. W. Orr, C. A. Peebles, R. R. Poux, W. C. Reichow, N. B. Roberts, H. S. Ross, C. V. Schutt, E. F. Snyder, L. S. Strohl, S. Thorvaldson.

In Bulletin 551, June–July 1959, your committee presented the first progress report on the study of the effectiveness of anti-splitting devices for the reduction of splitting in cross ties, which work is being conducted by the AAR research staff.

The following report summarizes the work conducted but not covered in the first progress report, and is presented as information.

A cooperative test with the Erie Railroad is under way in which 400 ties (or deviations as noted), divided into the following groups, were seasoned 18 months, treated, and put in track during the first part of July 1959:

1. Control ties having no device applied (600 ties).
2. Ties with crinkled, ribbed S-irons applied out-of-face before seasoning.
3. Ties with crinkled, ribbed S-irons applied out-of-face after seasoning.
4. Ties with bands—"tie belts"—applied after seasoning to badly split ties (13).
5. Ties with dowels applied out-of-face after seasoning.
6. Ties selectively dowelled after seasoning.
   a. Ties selected for dowelling.
   b. Ties remaining which were not dowelled.

These were all good-quality mixed red and white oak ties. No dowels were applied to green ties, although the standard practice is to use two S-irons in each end of the tie—applied while the tie is green—because the test was not set up sufficiently early to do so. Use was made of available ties having no device applied.

The seasoning period was fairly cool and wet, which probably produced less splitting than hotter, dryer weather would have. The basis for selectively dowelling a tie was the presence of a split $\frac{1}{32}$ in or more wide between two faces or $\frac{1}{16}$ in or more wide from one face to the pith. Of 844 ties inspected 417 were selected for dowelling, leaving 427 which were not dowelled. Both ends of the tie were dowelled even if the tie had a split on only one end. Two dowels were applied 4 in from each end.

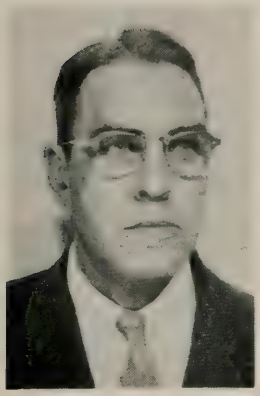
Facilities were not available for squeezing the tie ends before applying the S-irons. Consequently, they were applied without closing the splits.

These ties were applied as renewals in two test sections near Elmira, N. Y. So far as possible 200 test ties from each test group were installed in each test section. In this way the chance of a derailment completely nullifying any one test group is greatly reduced.

The following schedule of work is planned for 1960:

1. Continuing the inspections of field tests which are now under way, as follows:
   a. Bessemer & Lake Erie
      (1) Ties dowelled 6 in from the end and S-ironed ties
   b. Pennsylvania
      (1) Dowelled and sharon-ironed air-seasoned ties—2917 ties in two test sections
      (2) Dowelled and sharon-ironed–boulton-treated—1235 ties
      (3) Dowelled combined seasoned and treated ties
      (4) Laminated ties
      (5) Banded ties
   c. Erie
      (1) Ties dowelled 4 in from ends—S-ironed control ties—1955
      (2) Control ties, S-ironed ties before seasoning, S-ironed ties after seasoning, selective dowelling (split ties dowelled and others not dowelled) after seasoning, out-of-face dowelling after seasoning, banded, 1959, 2613 ties
   d. Louisville & Nashville
      (1) Coated ties and control S-ironed ties—1950—240 ties
   e. Illinois Central
      (1) Ties subjected to combined seasoning and treatment process.
      (2) Dowelled and C-ironed ties, control ties.
   f. Santa Fe
      (1) Ties subjected to combined seasoning and treatment process.
2. Field test of effect of saw kerfs on splitting during seasoning.
3. Collaborating with railroads which have 8 to 10-year-old ties in track which might be suitable for establishing comparative tests between anti-splitting devices, including ties treated by the combined seasoning and treatment process and vapor-dried ties.
4. Clock drilling of all test ties in track for positive identification in later years.

Report of Committee 17—Wood Preservation



P. D. Brentlinger,
Chairman,
R. B. Radkey,
Vice Chairman,

A. B. Baker
W. W. Barger
R. S. Belcher (E)
W. S. Brown
W. E. Buehler (E)
C. M. Burpee
C. S. Burt
G. B. Campbell
H. B. Carpenter
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R. F. Dreitzler
H. R. Duncan
F. J. Fudge
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R. R. Poux
M. H. Priddy
W. C. Reichow
A. P. Richards
R. B. Smith
W. B. Stombock
F. H. Taylor
R. G. Zeitlow
Committee

(E) Member Emeritus.
* Died July 20, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, including recommended revisions ..... page 417
2. Specifications for wood preservatives.
   Progress report, including Manual material presented for adoption, revision and reapproval ..... page 418
3. Specifications for petroleum as a carrier for standard wood preservatives.
   Progress report, presented as information ..... page 421
4. Specifications for preservative treatment of forest products, including laminated timbers, collaborating with Committees 6 and 7.
   Final report will be presented on revision of Manual next year after final action on preservatives presented under Assignment 2.
5. Conditioning of wood before preservative treatment.
   Committee continues to keep abreast of current and new methods and processes for the conditioning of wood before treatment.
7. Service test records of treated wood.
   The committee was instructed to report on test records of treated lumber and bridge material, but no report is presented because of lack of service records. Next year the committee will report on service records of cross ties.

8. Destruction by marine organisms; methods of prevention, collaborating with Committees 6 and 7.
   Progress report, presented at information ..... page 422

9. Destruction by termites; methods of prevention.
   This is a research project. One progress report has been presented to the Association; a later progress report will be made on field observations. Additional stakes containing other preservative solutions have been added to the test.

10. Incising forest products.
    The effect of incising forest products, especially cross ties, for the control of checking and splitting and for increasing the penetration of preservatives continues under study by the committee.

THE COMMITTEE ON WOOD PRESERVATION,
P. D. BRENTLINGER, *Chairman.*

AREA Bulletin 554, December 1959.

MEMOIR

Ben David Howe

Ben David Howe, chief lumber inspector of the Louisville & Nashville Railroad, died suddenly in Montreat, N. C., on July 20, 1959, following a heart attack which occurred while he and Mrs. Howe were vacationing on the beach at Montreat. He is survived by his wife, Mrs. Maybelle Wheeler Howe, two daughters, one son, and three grandchildren.

Mr. Howe was born on September 5, 1893, at Elizaville, Ky., He was graduated from the University of Kentucky as a civil engineer in 1916 and entered the service of the Louisville & Nashville as a draftsman on July 30 of that year.

Mr. Howe joined the American Railway Engineering Association on June 5, 1933. He became a member of Committee 17—Wood Preservation in 1942. He was also a member of Committee 3—Ties, and gave capable leadership to that important committee as its chairman during the period from April 1949 to March 1952. He gave valued service to Committee 5—Forest Products of the Association of American Railroads from 1956 through 1959. He was a member of the American Wood Preservers' Association for many years and served as president of that organization in 1955.

Mr. Howe was a diligent worker on all of the committees with which he served and evidenced more than usual interest in all committee affairs. In addition to his capacity for work, he had an attractive and pleasing personality and a keen sense of humor. Truly, it can be said he lived a full and useful life, devoted to his family, his church, and his work.

Mr. Howe had a great capacity for friendship. He leaves a host of friends, particularly throughout the railroad and wood preserving industries, who are well acquainted with the sterling qualities which made his friendship so very pleasant at all times. His sound knowledge, judgment, counsel, and genial ways will be greatly missed during the years ahead.

CLARENCE BURT, *Chairman,*
ROBERT B. RADKEY
H. R. DUNCAN
Committee on Memoir

Report on Assignment 1

Revision of Manual

C. S. Burt (chairman, subcommittee), W. W. Barger, R. S. Belcher, P. D. Brentlinger, Walter Buehler, C. M. Burpee, G. B. Campbell, L. C. Collister, D. L. Davies, H. R. Duncan, F. J. Fudge, M. S. Hudson, R. P. Hughes, A. J. Loom, T. H. Patrick, R. R. Poux, A. P. Richards, R. B. Smith.

Your committee offers the following recommendations with respect to Chapter 17 of the Manual.

Pages 17–1–1 and 17–1–2

FUNDAMENTALS

Reapprove with the following changes:

In the last paragraph on page 17–1–1, change the last sentence to read:
"Steaming is applied most generally to species such as southern pine, but is also used for the pre-conditioning of such species as Pacific Coast Douglas fir, intermountain Douglas fir, western larch, and western hemlock, when a water-borne salt preservative is to be used, or when the end use requires a particularly dry surface, even though the preservative is of an organic nature."

Page 17–1–3

PRESERVATIVES

Reapprove with the following changes:

Change the second paragraph to read:

"Creosote is often mixed with coal tar or petroleum to decrease the cost, increase the water-repelling properties and retard evaporation of the preservative. The addition of coal tar or petroleum generally results in the treated wood having somewhat oily surfaces; therefore, these admixtures are not suitable for poles. Creosote-petroleum solutions must not be used in marine-borer-infested waters."

Change the third paragraph to read:

"Water-borne preservatives are generally used where an odorless, paintable product is desired. They are highly toxic but less permanent than creosote under service conditions where the wood is in contact with water or subject to excessive wetting."

Page 17–1–3 and 17–1–4

PLANT PRACTICE

Reapprove without change.

Page 17–1–5 and17–1–6

RECORDS OF TREATMENT AND REPORTS OF INSPECTION

Reapprove with following addition:

Add just beneath the word "Date" on page 17–1–5:

Weather
- Temperature
- Snow
- Rain

Page 17–1–6

REQUISITIONING PRESERVATIVELY TREATED WOOD

Reapprove with the following change:

Change Par. e to read:

e. *Preservative.* An impregnant which meet the requirements of one of the AREA specifications for preservatives in accordance with use requirements: i.e., creosote, creosote-coal tar solutions, creosote-petroleum solutions, copper naphthenate, pentachlorophenol, zinc chloride, chromated zinc chloride, tanalith, acid copper chromate, copperized chromated zinc chloride, chromated zinc arsenate, ammoniacal copper arsenite, and chromated copper arsenate.

Report on Assignment 2

Specifications for Wood Preservatives

W. W. Barger (chairman, subcommittee), Walter Buehler, D. L. Davies, M. S. Hudson, L. W. Kistler, P. B. Mayfield, T. H. Patrick, A. P. Richards, R. B. Smith.

As indicated in the following, the report on this assignment is made up of five parts. In four of the five parts of the report your committee submits recommendations with respect to Chapter 17 of the Manual.

Part 1—Keep Up-To-Date Current Specifications for Preservatives

The present specification for creosote—coal-tar solutions makes no allowance for the decrease in distillate up to 235 deg C in solutions due to treatment operations. Your committee is of the opinion that Note 1 at the bottom of the specifications should be changed to include a minimum allowable distillate of 2.0 percent in used solutions. This would also bring the specification in line with similar specifications of other associations. The specific recommendation of your committee is as follows:

Page 17–2–2

CREOSOTE—COAL-TAR SOLUTIONS

Reapprove wth the following revisions:

Delete present Note 1, substituting the following:

Note 1—Due to treating operations, samples of used creosote—coal-tar solutions may show increases in matter insoluble in benzol, and in coke residue, and decreases in the percentage of distillate up to 235 deg C. If it can be shown that the original solution was of the specified quality, and the used solution conforms to the standard requirements with the following exceptions:

	Grade A	*Grade B*	*Grade C*	*Grade D*
Benzol insoluble matter, max, percent	*3.0*	*4.0*	*4.5*	*5.0*
Coke residue, max, percent	*6.0*	*8.0*	*10.0*	*12.0*
Distillate up to 235 deg C, min, percent	*2.0*	*2.0*	*2.0*	*2.0*

it shall be considered as conforming.

Add to Item 6. Distillation, in the tabulated portion of the specification the words "See Note 1".

Part 2—Review and Report on New Preservatives

Your committee has studied two new preservatives: fluor-chrome-arsenic-phenol Type B (Osmosalts) and copperized chromated zinc arsenate (copperized Boliden salts), and recommends the acceptance of these two preservatives as standards to be printed in the Manual. Because of the similarity of the components of Tanalith and Osmosalts, it is proposed next year to change "Tanalith" to "fluor-chrome-arsenic-phenol Type A."

The two preservatives recommended for adoption and publication in the Manual are as follows:

FLUOR-CHROME-ARSENIC-PHENOL TYPE B

Fluor-chrome-arsenic-phenol Type B shall be composed of the following ingredients in the proportions given:

	Percent
Fluoride calculated as sodium fluoride (NaF)	34
Arsenate calculated as disodium hydrogen arsenate (Na_2HAsO_4)	25
Bichromate calculated as sodium bichromate ($Na_2Cr_2O_7H_2O$)	34
Dinitrophenol	7

Subject to the following tolerances:

The minimum proportions may be, respectively, 31, 22, 31, and 5, but the preservative shall contain at least 95 percent of these active materials. The pH of the treating solution shall be not less than 5.5 nor more than 6.5.

The foregoing tests shall be made in accordance with the standard methods of the AWPA (see AWPA Manual, Sec. A2).

Comment

Fluor-chrome-arsenic-phenol Type B is recommended for preservative treatment of all classes of wood except marine piling. However, water-soluble salt treatments as a general rule have not been found entirely satisfactory for cross ties because they do not help to protect the wood mechanically, are subject to leaching over long periods and, thus, will decay and affect circuit conductivity.

For general use where leaching is not an important factor, the following retentions of fluor-chrome-arsenic-phenol Type B are recommended.

For use in contact with the ground not less than 0.55 lb/cu ft; for use above ground, not less than 0.35 lb/cu ft.

COPPERIZED CHROMATED ZINC ARSENATE

Copperized chromated zinc arsenate in the solid state shall be composed of the following ingredients in the proportions given:

	Percent
Arsenic acid (H_3AsO_4)	21
Sodium arsenate (Na_2HAsO_4)	20
Sodium dichromate ($Na_2Cr_2O_7.2H_2O$)	16
Zinc sulfate $.7H_2O$	21.5
Copper sulfate $.5H_2O$	21.5

The proportions of the ingredients in the solicd preservative or in the treating solution shall conform to the following minimums:

	Percent
Arsenic acid (H_3AsO_4)	19
Sodium arsenate (Na_2HAsO_4)	18
Sodium dichromate $Na_2Cr_2O^7H_2O$)	14
Zinc sulfate ($ZnSO_4.7H_2O$)	20.5
Copper sulfate ($CuSO_4.5H_2O$)	20.5

The solid preservative shall be considered to meet the requirements with respect to arsenic compounds if the total arsenic content calculated as As_2O_5 is not less than 27 percent and the pH of a solution containing 25 grams per liter of the solid preservative measured at 25 deg C lies between 2.90 and 3.50.

The preservative shall contain at least 95 percent of the active ingredients listed above.

The foregoing tests shall be made in accordance with the standard methods of the AWPA (see AWPA Manual, Sec. A2).

Comment

Copperized chromated zinz arsenate is recommended for preservative treatment of all classes of wood except marine piling. However, water-soluble salt treatments as a general rule have not been found entirely satisfactory for cross ties because they do not help to protect the wood mechanically, are subject to leaching over long periods and, thus, will decay and affect circuit conductivity.

For general use where leaching is not an important factor, the following retentions of copperized chromated zinc arsenate are recommended:

For use in contact with ground, not less than 1.0 lb/cu ft; for use above ground, not less than 0.5 lb/cu ft.

Part 3—Review Method of Sampling Creosote in Tank Cars

Your committee has concluded its study of this subject and is of the opinion that the AWPA Standard Methods for Sampling Wood Preservatives, A4, should be accepted as an AREA standard. These methods of sampling include, in addition to a method for sampling creosote in tank cars, methods for sampling other preservatives. At the present time the AREA Manual does not have standard methods for sampling preservatives other than creosote.

Accordingly, your committee recommends the deletion of Method of Sampling Creosote in Tank Cars, Manual pages 17–3–5 to 17–3–9, incl., and the substitution therefor of the following:

STANDARD METHODS FOR SAMPLING WOOD PRESERVATIVES

See AWPA Manual, Sec. A4.

Part 4—Review "Comments" After Preservative Specifications; Report on Need for Comments with View Toward Continuance, Deletion or Change of Title

Your committee has studied this subject and has come to the conclusion that the comments following water-soluble salt specifications should be retained in a revised form and added to those water-soluble salt specifications that do not at present have the comment, the necessary changes to be made in the individual specifications when they are otherwise revised or reapproved in 1961 and 1962.

The revised form of the comments will read as follows (with the name of the salt preservative substituted for the blank):

..... is recommended for preservative treatment of all classes of wood except marine piling. However, water-soluble salt treatments as a general rule have not been found entirely satisfactory for cross ties because they do not help to protect the wood mechanically, are subject to leaching over long periods and, thus, will decay and affect circuit conductivity.

This revision applies only to the first paragraph under the heading "Comment", in those specifications that now have it. The present paragraphs in the "Comment" giving the recommended retentions of the preservative will not be changed.

Part 5—Reapproval of Present Manual Material

Your committee offers the following further recommendations with respect to Part 3, Chapter 17.

Pages 17–3–1 and 17–3–2

STANDARD VOLUME CORRECTION TABLE FOR CREOSOTE–PETROLEUM

Reapprove without change.

Pages 17–3–3 and 17–3–4

VOLUME CORRECTION FOR TEMPERATURE IN THE MEASUREMENT OF CREOSOTE

Reapprove without change.

Pages 17–3–11 and 17–3–12

STANDARD ABRIDGED VOLUME CORRECTION TABLES FOR PETROLEUM OILS

Reapprove without change.

Pages 17–3–13 and 17–3–14

VOLUME CORRECTION FACTORS FOR PRESERVATIVE SALT SOLUTIONS

Reapprove without change.

Report on Assignment 3

Specifications for Petroleum as a Carrier for Standard Wood Preservatives

T. H. Patrick (chairman, subcommittee), W. W. Barger, H. B. Carpenter, L. C. Collister, R. F. Drietzler, H. R. Duncan, R. G. Zeitlow.

This is a progress report, presented as information.

Last year your committee presented for adoption a specification for petroleum oil as a carrier for pentachlorophenol. At that time there was some objection to the minimum distillation range of 90-percent point not lower than 600 deg F. This matter was again surveyed, but since no apparent hardship has been experienced, no change is recommended at this time. The studies will be continued, however.

In its studies your committee has found that a lighter oil is being recommended for blending with pentachlorophenol to be used for treating material that is to be

painted after treatment. The committee has reached no conclusion on this recommendation as it needs further study.

Below is a suggested oil specification that one association has published for information.

Gravity API	40–52	ASTM Method D 287
Distillation:		
IBFF	300 Min	
FBFF	410 Min	
Aniline Cloud Point, F	100–145	ASTM Method D 1012
Kauri Butanol No.	33–43	ASTM Method D 1133
Flash Point, F	100 Min	
Appearance	Clear	
Odor	Mild	

It is recommended that studies on petroleum carriers for wood preservatives be continued.

Report on Assignment 8

Destruction by Marine Organisms: Method of Prevention

A. P. Richards (chairman, subcommittee), Walter Buehler, C. M. Burpee, R. F. Deitzler, H. M. Harlow, B. D. Howe, P. B. Mayfield, F. H. Taylor.

The instructions to your committee in regard to this assignment are to report on destruction by marine organisms, with a view toward recommending to the proper committee specifications for methods of prevention.

The following report, for the period 1959–60, is submitted as information, and is concerned with the activities of destructive marine organisms and procedures to prevent such deterioration.

PROGRESS REPORTS ON TEST PILES AND SPECIMENS

Through the courtesy of W. M. Jaekle, chief engineer of the Southern Pacific Company, the results of the latest inspections of the following test programs are presented. The inspections of the test samples were made by R. M. Alpen, manager of wood preserving plants for the Southern Pacific.

Report of the December 17, 1958, Inspection of Specimens Furnished by the Chemical Warfare Service and Placed on Test in San Francisco Bay at the Request of the Late Dr. Herman von Schrenk

Gate 25–1–A—Installed at Biological Station, Oakland Pier, July 1925, removed 1942, replaced 1946. The untreated pieces hung at this station in 1958 had heavy limnoria attack, with an average weight loss of 48 percent.

No. 2—(Creosote and 1 percent diphenylamine chlorarsine). The last inspection in 1957 showed a heavy limnoria attack present. Panels reported lost in 1958.

Chemical Warfare Service Test Pieces Forwarded from Edgewood Arsenal by Lt. Col. C. E. Brigham and Hung at Oakland Pier, February 1932, Removed 1942, Replaced 1946

Specimen	*Treatment*	*Condition*
A–11	Creosote, 21.6 lb/cu/ft	Heavy limnoria attack
D–11	Creosote plus 2½% dinitrophenol, 23.7 lb/cu/ft	Heavy limnoria attack

REPORT OF INSPECTION DECEMBER 17, 1958 OF SPECIMENS FURNISHED THROUGH DR. H. VON SCHRENK AND COL. WM. G. ATWOOD AND INSTALLED IN SAN FRANCISCO BAY AREA

Barrett Manufacturing Company material placed at Station B, Pier 7, San Francisco, January 1923, moved to Biological Station, Oakland Pier, December 1925. Removed 1942, replaced 1946. Total exposure to date 32 years. (P—Pine; F—Fir)

Gate	*Specimen*	*Treatment*	*Condition*
B-4	P-1	Coke oven, original	50% destroyed.
	P-2	Coke oven, solids removed	Heavy limnoria attack.
	P-3	Coke oven, acids removed	Heavy limnoria attack.
	P-4	Coke oven, bases removed	Heavy limnoria attack.
B-5	P-5	Coke oven, oil minus residue at 360°C.	Reported lost.
	P-6	Coke oven, oil minus fraction 230–270	Reported lost.
	P-7	Coke oven, oil minus fraction up to 230	Reported lost.
	P-8	Coke oven, oil minus fraction 270–360	Reported lost.
B-6	P-9	Vertical retort, original oil	Very heavy limnoria attack.
	P-10	Vertical retort, minus solids	Very heavy limnoria attack.
	P-11	Vertical retort, minus acids	50% destroyed.
	P-12	Vertical retort, minus bases	50% destroyed.
B-7	P-13	Vertical retort, minus residue above 360°C.	Reported lost.
	P-14	Vertical retort, minus fraction 230–270°	Reported lost.
	P-15	Vertical retort, minus fraction up to 230°C.	Reported lost.
	P-16	Vertical retort, minus fraction 270–360°	Reported lost.
B-8	F-1	Same as P-1	Very heavy limnoria attack.
	F-2	Same as P-2	Moderate limnoria attack.
	F-3	Same as P-3	Heavy limnoria attack.
	F-4	Same as P-4	Moderate limnoria attack.
B-9	F-5	Same as P-5	Reported lost.
	F-6	Same as P-6	Reported lost.
	F-7	Same as P-7	Reported lost.
	F-8	Same as P-8	Reported lost.
B-10	F-9	Same as P-9	Heavy limnoria attack.
	F-10	Same as P-10	50% destroyed by limnoria.
	F-11	Same as P-11	Heavy limnoria attack.
	F-12	Same as P-12	Heavy limnoria attack.
B-11	F-13	Same as P-13	Very heavy limnoria attack.
	F-14	Same as P-14	Heavy limnoria attack.
	F-15	Same as P-15	Heavy limnoria attack.
	F-16	Same as P-16	Heavy limnoria attack.

Untreated specimens at this station in 1958 show heavy limnoria attack; average loss in weight was 48 percent.

Hercules Powder Company products exposed from 1948 to 1958 were found to be in the following condition:

Rosinamine D ..... Destroyed

Cuprolignum-treated samples exposed from 1948 to 1958 were found to be in the following condition:

Cu_3, pressure treated ..... Heavy limnoria attack, about ½ destroyed.
Copper naphthenate, pressure treated ..... Heavy localized limnoria attack

---

Four samples exposed April 5, 1950, to 1958 were as follows:

Standard Oil (of Calif.) Wood Preservative
No. 1, 6 lb/cu/ft ..... Previously reported destroyed (1954).
No. 2, 13.7 lb/cu/ft ..... Almost destroyed by limnoria.

Creosote

No. 1, 12.6 lb/cu/ft ..... Moderate limnoria attack.
No. 2, 6.2 lb/cu/ft ..... Almost destroyed by limnoria.

Five samples treated with "Gasco" oils (Portland Gas & Coke Co.), exposed October 1951, were reported to be as follows in 1958:

HC	Gasco creosote	14.6 lb/cu/ft	.....	Light limnoria activity.
LC	" "	6.6 lb/cu/ft	.....	Moderate " "
HD	" distillate	13.0 lb/cu/ft	.....	Light " "
MD	" distillate	10.3 lb/cu/ft	.....	Heavy " "
LD	" distillate	3.9 lb/cu/ft	.....	Heavy " "

The following pieces treated with various preservatives were placed on test January 20, 1954, at West Oakland with the following results in December 1958:

CL	Creosote	7.45 lb/cu/ft	.....	Heavy localized limnoria attack.
CM	"	10.58 lb/cu/ft	.....	Almost destroyed.
CH	"	11.21 lb/cu/ft	.....	Moderate limnoria attack.
CRL	"	13.24 lb/cu/ft	.....	Heavy localized limnoria attack.
CRM	"	18.97 lb/cu/ft	.....	Heavy limnoria attack.

TEST BOARD STUDIES

The marine borer test panel studies at the William F. Clapp Laboratories, Inc., located in Duxbury, Mass., which have been in continuous operation for over 20 years, are being continued. By means of the monthly laboratory examination of untreated panels which have been submerged at approximately 300 locations on a nearly world-wide basis, long-range marine borer activity may be studied and evaluated from an engineering standpoint as well as for a basis of fundamental research. Annual reports dealing with these studies are published and may be obtained without charge from the Laboratories. Those sponsoring the work are the Navy Department, Bureau of Yards and Docks, as well as a number of private organizations.

AWPI—FPL COOPERATIVE CREOSOTED PILE PROJECT

The American Wood Preserving Institute has entered into a cooperative project with the Forest Products Research Laboratory in which the latter is engaged in analyzing the preservative content of creosoted piling, in the "below mud line" sections, which has been in actual service. Piling which have given excellent service, as well as failures, are being investigated whenever possible. The project is now only eight months old, and the results are merely preliminary. The recently developed assay method of analysis in which the actual oil is removed from the piling sections is being used under the direction of Dr. Roy Baechler of the Forest Products Laboratory.

MARINE PILE SERVICE TESTS

In 1950 two full-size piles were incorporated into the wharf at the International Nickel Company, Inc., marine research station at Wrightsville Beach, N. C. These were inspected in September 1959 with the following results:

Pine, Treated with Erdalith

No. C–3 3.42 lb/cu/ft dry salt .....No attack.
No. C–4 3.61 lb/cu/ft dry salt .....No attack.

Report of Committee 29—Waterproofing

E. A. Johnson, *Chairman,*
R. J. Brueske,
Vice Chairman,

W. H. Acker, Jr.
A. L. Becker
D. E. Bray
Lyle Bristow
M. W. Bruns
W. H. Bunge
A. E. Cawood
G. W. Clarvoe
E. T. Franzen
J. M. Gilmore
W. G. Harding
W. P. Hendrix
E. K. Herling
R. L. Mays
L. H. Needham
B. J. Ornburn
H. A. Pasman
R. A. Peteritas
Milton Pikarsky
R. D. Powrie
W. E. Robey
Jack Schmidt
F. S. Schubert
Henry Seitz
T. M. von Sprecken
J. W. Weber
C. A. Whipple (E)
H. J. Wilkins
J. M. Williams
K. B. Wood
Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   In connection with the proposed reprinting of the Manual in 1962, the committee is revising Part 4 of Chapter 29. The changes now proposed will make this part consistent with Parts 1 through 3.

2. Waterproofing membranes for bridge decks, collaborating with Committees 8 and 15.
   Progress report, submitted as information ..... page 426

3. Coatings for dampproofing railway structures, collaborating with Committees 6 and 8.
   Progress report, submitted as information ..... page 426

4. Protective cover and underlayment for membranes.
   Preliminary work only has been done. Tests to determine a satisfactory mix formulated from materials of gradations available on the market have not yet been started.

The Committee on Waterproofing,
E. A. Johnson, *Chairman.*

Report on Assignment 2

Waterproofing Membranes for Bridge Decks

Collaborating with Committees 8 and 15

E. T. Franzen (chairman, subcommittee), W. H. Acker, Jr., D. E. Bray, M. W. Bruns, G. W. Clarvoe, B. J. Ornburn, Milton Pikarsky, R. D. Powrie, Jack Schmidt, J. M. Williams.

Your committee submits the following progress report as information.

Tests of waterproofing membranes and materials are continuing at the AAR Research Center, Chicago. Several new materials have recently been tested which show promise of being valuable additions to the field of waterproofing materials. It is anticipated that the work on testing of membranes and materials will be completed in 1960 and a report published that year.

Part 2—Membrane Waterproofing of Chapter 29 is being completely rewritten and will incorporate ASTM specifications wherever applicable. A draft of the rewritten specification was reviewed by the committee at its meeting in Pittsburgh on November 5 and 6 and will be submitted for approval at the 1961 AREA Convention.

The rewriting is being done to get the material arranged in better order for ease in reading and understanding.

Report on Assignment 3

Coatings for Dampproofing Railway Structures

Collaborating with Committees 6 and 8

W. P. Hendrix (chairman, subcommittee), A. L. Becker, Lyle Bristow, W. H. Bunge, J. M. Gilmore, W. G. Harding, R. A. Peteritas, F. S. Shubert, Henry Seitz, K. B. Woods, L. H. Needham, J. W. Weber.

Last year your community reported on the progress of the testing of water-repellent coating materials being carried out at Purdue University under the direction of W. L. Dolch, research associate.

The final report on this work, entitled "Factors Affecting the Penetration by Water of Bituminous and Silicone Coatings", was published in Bulletin 552, September–October 1959.

The study dealt with bituminous emulsions and silicone resins. The amount of water that can penetrate an intact film of bituminous material is negligible. Failure of bituminous materials is primarily the result of imperfect application. The capillary properties of both these types of coatings are a guide to their serviceability. The degree of water penetration is partially determined by the contact angle of water on the material. Water will be admitted if the angle is less than 90 deg, and will be denied entrance if the angle is over 90 deg. The contact angles of water on the various materials were measured and the influence of weathering exposure was studied. Two weathering processes were employed. One was a wetting and drying procedure, the other made use of a laboratory weathering machine.

Four types of bituminous emulsions were evaluated. These were coal tar, soap-type asphalt, soap-type asphalt, filled, and clay-type asphalt. The silicones were manufacturer's

samples. Three were solvent-base materials and two were water-base materials. The bituminous films were prepared by filling brass molds to produce a film 4 in. in diameter and about 0.02 in thick. The bituminous films thus produced were applied to 6- by 6-in glass plates. The silicones were also applied to 6- by 6-in glass plates. Several concentrations of silicone solutions were used. The height of a drop of water placed on the samples was measured by means of an Ames dial, from which the contact angles were developed.

The report concludes that:

1. Weathering processes influence the contact angle of water. This factor is important to the sreviceability of the material.
2. Considerable differences exist among various materials with respect to their susceptibility to change of contact angle with water through weathering.
3. Coal-tar emulsions may be more susceptible than asphalt emulsions to decreases of contact angle with water.
4. Immersion lowers the contact angle of water on bituminous emulsions and drying restores the original value; therefore water should be drained from coatings as soon as possible.
5. Clay-type asphalt emulsion coatings are apparently surface roughened by weathering processes.
6. The contact angle of water on silicone films is lowered by weathering.

Report of Committee 30—Impact and Bridge Stresses

D. W. Musser, *Chairman,*
J. W. Davidson,
Vice Chairman,

E. R. Andrlik
D. S. Bechly
J. M. Bentham
E. S. Birkenwald
E. R. Bretscher
K. L. DeBlois
W. E. Dowling
C. E. Ekberg, Jr.
N. E. Ekrem
D. J. Engle
J. A. Erskine
R. J. Fisher
A. T. Granger
A. R. Harris
R. H. Heinlen
C. V. Lund
J. F. Marsh
James Michalos
P. L. Montgomery
W. H. Munse
C. H. Newlin
N. M. Newmark
A. L. Piepmeier
M. J. Plumb
E. W. Prentiss
H. C. Prince
C. A. Roberts
M. B. Scott
J. H. Shieber
A. P. Smith
C. B. Smith
J. E. South
L. F. Spaine
F. W. Thompson
G. S. Vincent
J. R. Williams
E. N. Wilson
L. W. Wood
J. D. Woodward
M. O. Woxland
L. T. Wyly
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Steel girder spans.
   Final report, presented as information ..... page 430

2. Steel truss spans.
   At the request and expense of the Florida East Coast Railway, a service test was made during 1959 on a double-track 216 ft long Strauss bascule through-truss span over the St. John's River at Jacksonville, Fla., to determine the stresses in the vicinity of the counterweight during the opening and closing of the bridge.

3. Viaduct columns, collaborating with Committee 15.
   No progress was made on this assignment this year. Generally this assignment has been progressed in conjunction with tests on other subjects. However, the type of structures which were tested and analyzed this year precluded the possibility of any progress on this assignment.

4. Longitudinal forces in bridge structures, collaborating with Committees 7, 8 and 15.
   Progress report, presented as information ..... page 431

5. Distribution of live load in bridge floors:
   (a) Floors consisting of transverse beams.
   (b) Floors consisitng of longitudinal beams.
   Progress report, presented as information ..... page 431

6. Concrete structures, collaborating with Committee 8.
   Progress report, presented as information ..... page 432

7. Timber structures, collaborating with Committee 7.
   Progress report, presented as information ..... page 432

8. Vibrational characteristics of bridges affecting deflections and depth ratios. An analytical study was started in the Department of Civil Engineering, New York University, in January 1957, to determine the effects of various parameters on the vibrational characteristics of railroad bridges. A method of analysis has been developed and programmed for solution by use of a digital computer, and a few preliminary studies have been completed. However, this study has been suspended for the present because of lack of funds.

9. Use of electronic computers for railroad bridge problems.
Progress report, presented as information ..... page 433

10. Steel continuous structures, collaborating with Committee 15.
Progress report, presented as information ..... page 433

11. Composite design of steel structures having concrete decks, collaborating with Committees 8 and 15.

Work during the year has consisted of assembling ideas regarding the type of research on this subject that will be of greatest value and interest to railroad engineers without duplicating the extensive research already carried out or being carried out by others.

The Committee on Impact and Bridge Stresses,
D. W. Musser, *Chairman.*

AREA Bulletin 554, December 1959.

Report on Assignment 1

Steel Girder Spans

M. J. Plumb (chairman, subcommittee), E. R. Andrlik, D. S. Bechly, E. R. Bretscher, W. E. Dowling, H. C. Prince, C. A. Roberts, J. H. Shieber, A. P. Smith, C. B. Smith, L. T. Wyly.

A summary report of the tests on girder spans was published in Bulletin 551, June–July 1959. It covers an extensive series of tests on 37 girder spans, and shows that revised impact equations for girder spans would be of definite benefit to the railroads.

These tests indicate that the use of higher impact values for some spans but lower values for other spans, notably ballasted-deck spans, would more accurately reflect actual test values and would provide a more uniform factor of safety.

Proposed new impact equations for girder spans are presented in the report.

Report on Assignment 4

Longitudinal Forces in Bridge Structures

Collaborating with Committees 7, 8 and 15

J. A. Erskine (chairman, subcommittee), J. M. Bentham, C. V. Lund, J. F. Marsh, A. L. Piepmeier, C. A. Roberts, L. F. Spaine, M. O. Woxland, L. T. Wyly.

A report on tests conducted on four ballasted-deck timber pile trestles located on the double-track main line of the Santa Fe Railway near Powell, Ariz., appears in Bulletin 552, September–October 1959. This report contains data on the bending stresses in the piles, pressure of the backwalls against the embankments, and tensile and compressive stresses in the running rails caused by braking of the test train to a stop on the bridge and by traction of the test train starting on the bridge.

Report on Assignment 5

Distribution of Live Load in Bridge Floors

(a) Floors Consisting of Transverse Beams

(b) Floors Consisting of Longitudinal Beams

N. M. Newmark (chairman, subcommittee), D. S. Bechly, E. S. Birkenwald, J. W. Davidson, K. L. DeBlois, R. J. Fisher, C. H. Newlin, E. W. Prentiss, J. E. South, E. N. Wilson, L. W. Wood, M. O. Woxland.

The work on this assignment during the last year has dealt mainly with an evaluation of the analytical procedures that have been selected to determine the beam moments and the use of these procedures to obtain a large number of solutions for various floor systems.

Two analytical methods have been used to determine the beam moments in the bridge structures. One is based upon an anisotropic plate theory and assumes the beams and the slab to be an integral unit. The second procedure is a moment-distribution method of analysis and assumes no horizontal shear transfer between the floorbeams and the slab.

In most instances the analyses have provided excellent correlations with the data from the bridge tests reported previously by this committee.

For the two types of bridges under consideration, beam moments due to single- and double-track loadings have been computed for various bridges with ballast depths up to 24 in, floor systems with various combinations of length, width and beam spacing, and different ratios of beam stiffness to slab stiffness.

Nearly all of the analytical results have been obtained and are being studied so that recommendations can be made for suitable design procedures and specifications. At this time, it is planned to have the final report on this assignment completed in 1960.

Report on Assignment 6

Concrete Structures

Collaborating with Committee 8

P. L. Montgomery (chairman, subcommittee), J. W. Davidson, W. E. Dowling, C. E. Ekberg, Jr., N. E. Ekrem, J. A. Erskine, R. H. Heinlen, C. V. Lund, James Michalos, N. M. Newmark, A. L. Piepmeier, J. H. Shieber, A. P. Smith, F. W. Thompson, J. R. Williams, J. D. Woodward.

The research staff of the Association of American Railroads has prepared plans for a number of beams with variable levels of prestress and different steel proportions. These beams will be used to continue the study of fatigue resistance of prestressed concrete. The laboratory testing of these beams will be progressed during 1960.

A general description and preliminary observations in connection with field tests made on two prestressed concrete bridges may be found in the Proceedings, Vol. 60, 1959, page 382. The analysis of test data on the Southern Railway bridge for both static and dynamic loading has nearly been completed by the research staff of the AAR and will be reviewed by this committee in 1960.

Report on Assignment 7

Timber Structures

Collaborating with Committee 7

C. V. Lund (chairman, subcommittee), E. R. Bretscher, K. L. DeBlois, D. J. Engle, R. H. Heinlen, C. H. Newlin, F. W. Thompson, J. R. Williams, L. W. Wood, J. D. Woodward, M. O. Woxland.

A report on tests conducted on four ballasted-deck timber pile trestles located on the double-track main line of the Santa Fe Railway near Powell, Ariz., appears in Bulletin 552, September–October 1959. The trestles are all of approximately 14 ft span length, and of low height; however, the deck construction of the two trestles on the eastbound track differed from that on the westbound.

Data obtained from tests conducted on a 60 ft long glued laminated girder span located on a Weyerhauser Timber Company logging spur near Longview, Wash., are being analyzed, and it is expected a report on this investigation will be submitted next year.

Report on Assignment 9

Use of Electronic Computers for Railroad Bridge Problems

E. R. Andrlik (chairman, subcommittee), D. S. Bechly, W. E. Dowling, J. Michalos, P. L. Montgomery, W. H. Munse, M. J. Plumb, E. W. Prentiss, H. C. Prince, L. F. Spaine, G. S. Vincent, J. R. Williams, E. N. Wilson.

Early in 1959 a computer program for calculating moments, shears, cross-girder reactions and Cooper E ratings for any system of moving loads on simple spans was completed and has been made available to the railroads. This program can be used to prepare moment and shear tables and will be employed as part of future programs for bridge rating or stress-analysis problems.

At present the program is being used to prepare moment and shear tables for at least 25 representative special heavy railroad cars. This set of tables is expected to be completed and made available to the railroads early in 1960.

Report on Assignment 10

Steel Continuous Structures

Collaborating with Committee 15

A. R. Harris (chairman, subcommittee), E. R. Andrlik, J. M. Bentham, E. S. Birkenwald, J. W. Davidson, D. J. Engle, R. J. Fisher, A. T. Granger, J. F. Marsh, W. H. Munse, D. W. Musser, H. C. Prince, C. B. Smith.

Field tests were conducted by the research staff of the AAR on three continuous steel span bridges on the Southern Pacific Company in 1957. A description of these tests is printed in the Proceedings, Vol. 60, 1959, page 384.

These bridges are on the main line of the Southern Pacific near Redding, Calif., and are:

1. Bridge No. 282.93, three 40-ft ballasted-deck plate girder spans.
2. Bridge No. 283.77, three 192-ft 6-in open-deck riveted truss spans.
3. Bridge No. 284.16, two 46-ft 8-in ballasted-deck through-plate girder spans.

The test data have been analyzed and a report has been prepared by the research staff of the AAR. This report has been reviewed by this committee and will be published sometime in 1960.

Report of Committee 22—Economics of Railway Labor

L. A. Loggins, *Chairman,*

J. E. Eisemann, *Vice Chairman,*

L. C. Gilbert, *Secretary,*

Lem Adams (E)
A. D. Alderson
M. B. Allen
R. M. Bailey
V. A. Barnhart, Jr.
J. F. Beaver
E. J. Brown
J. L. Cann
R. H. Carpenter
J. A. Caywood
A. B. Chaney
W. E. Chapman
B. S. Converse
S. A. Cooper
P. A. Cosgrove
C. G. Davis
L. R. Deavers
M. H. Dick
L. E. Donovan
W. M. S. Dunn
H. J. Fast
J. L. Fergus
R. L. Fox
R. J. Gammie*
R. A. Gravelle**
R. R. Gunderson
V. C. Hanna
W. W. Hay
W. H. Hoar
E. Q. Johnson
Claude Johnston
R. H. Jordan
T. L. Kanan
H. W. Kellogg
N. M. Kelly
H. E. Kirby
N. W. Kopp
J. M. Lowry
R. L. Mays
J. S. McBride (E)
J. R. Miller
H. C. Minteer
G. M. O'Rourke
R. W. Pember
C. T. Popma
R. R. Pregnall, Jr.
R. W. Preisendefer
Griffith Ray
M. S. Reid
D. E. Rudisill
H. W. Seeley
E. J. Sierleja
R. G. Simmons
J. S. Snyder
John Stang
A. H. Stimson
J. T. Sullivan
W. B. Throckmorton
J. T. Ward
H. J. Weccheider
N. H. Williams
H. M. Williamson
H. E. Wilson
F. R. Woolford
Committee

(E) Member Emeritus.
* Died October 19, 1959.
** Died June 20, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   The committee is assembling information that will be required for complete revision of its Manual material during the next two years in order that it might be included in the Manual when reprinted in 1962.

2. Analysis of operations of railways that have substantially reduced the cost of labor required in maintenance of way work.
   Progress report, presented as information ..... page 437

3. Relative economies to be derived from ownership vs rental of maintenance of way machinery, collaborating with Committee 27.
   Final report, presented as information ..... page 444

4. Labor economies to be derived from the use of modern equipment, optimum treating programs, and the most efficient chemicals for control of vegetation.
   Progress report, presented as information ..... page 449

5. Labor economies to be effected through the use of power tools and mechanized equipment by bridge and building gangs.
   Progress report, presented as information ..... page 449

6. Relative economies to be derived from the use of tie pads in various locations and under varying circumstances.
   Progress report, presented as information ..... page 454

7. The specific and ultimate improvements in various types of track maintenance equipment that would provide the greatest economies in maintenance practices and how these potential economies would compare with present costs, collaborating with Committee 27.
   Final report, presented as information ..... page 456

9. Relation between the nature of traffic and the interval between out-of-face resurfacing of tracks of relatively similar characteristics.
   Final report, presented as information ..... page 458

The Committee on Economics of Railway Labor,
L. A. Loggins, *Chairman.*

AREA Bulletin 554, December 1959.

MEMOIR

Raymond Arthur Gravelle

Raymond Arthur Gravelle, engineer maintenance of way, Grand Trunk Western Railroad, passed away on June 20, 1959. He is survived by his wife, Mrs. Florence K. Gravelle, Detroit, Mich.; a daughter, Mrs. Florence R. Oberg, and a granddaughter, Cathy Ann, of Oxford, Mich.

Mr. Gravelle was born in Detroit on September 25, 1896. He entered the service of the GTW on May 16, 1916, soon after graduating from high school, subsequently continuing his studies at the University of Detroit.

Mr. Gravelle devoted his efforts wholeheartedly and unstintingly to his railroad, capably filling the positions of rodman, instrumentman, assistant engineer, industrial engineer and engineer maintenance of way, the position he occupied at the time of his death. He was actively interested in the Social and Athletic Association of the road and served as an officer of the Association and on many of its committees.

Mr. Gravelle became a member of the American Railway Engineering Association in 1927 and served generously and faithfully on various committees of the Association. His fellow members respected him and had pleasure in working with him. In 1952, Mr. Gravelle became a member of the Roadmasters' and Maintenance of Way Association of America.

Mr. and Mrs. Gravelle attended the St. Andrews Lutheran Church of Detroit during the many years of their married life.

All of Mr. Gravelle's associates and friends sincerely regret his passing and feel privileged to have known and worked with him.

H. W. Kellogg
H. J. Fast
C. T. Popma
Committee on Memoir

Report on Assignment 2

Analysis of Operations of Railways That Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work

J. S. Snyder (chairman, subcommittee), M. B. Allen, R. M. Bailey, V. A. Barnhart, Jr., J. F. Beaver, E. J. Brown, J. L. Cann, R. H. Carpenter, S. A. Cooper, L. E. Donovan, W. M. S. Dunn, R. L. Fox, W. W. Hay, W. H. Hoar, Claude Johnston, R. H. Jordon, H. W. Kellogg, N. M. Kelly, H. E. Kirby, N. W. Kopp, J. M. Lowry, R. L. Mays, H. C. Minteer, C. T. Popma, R. W. Preisendefer, Griffith Ray, E. J. Sierleja, R. G. Simmons, John Stang, J. T. Sullivan, W. B. Throckmorton, J. T. Ward, W. J. Weccheider, N. H. Williams, H. E. Wilson.

This report is submitted as information.

Your committee is making the 18th report of a series on this subject which has been reassigned annually since 1935. The current study covers procedures in effect on the Southern Railway System to reduce its cost of handling track materials and, in particular, materials related to the welding of rail, cropping of relay rail, prefabrication of track panels, and turnouts. The committee inspected the property of the Southern at Atlanta, Ga., including its modern Inman Yard, a modern car repair installation, and the maintenance-of-way rail-welding and prefabricating plants designed for track construction and rehabilitation.

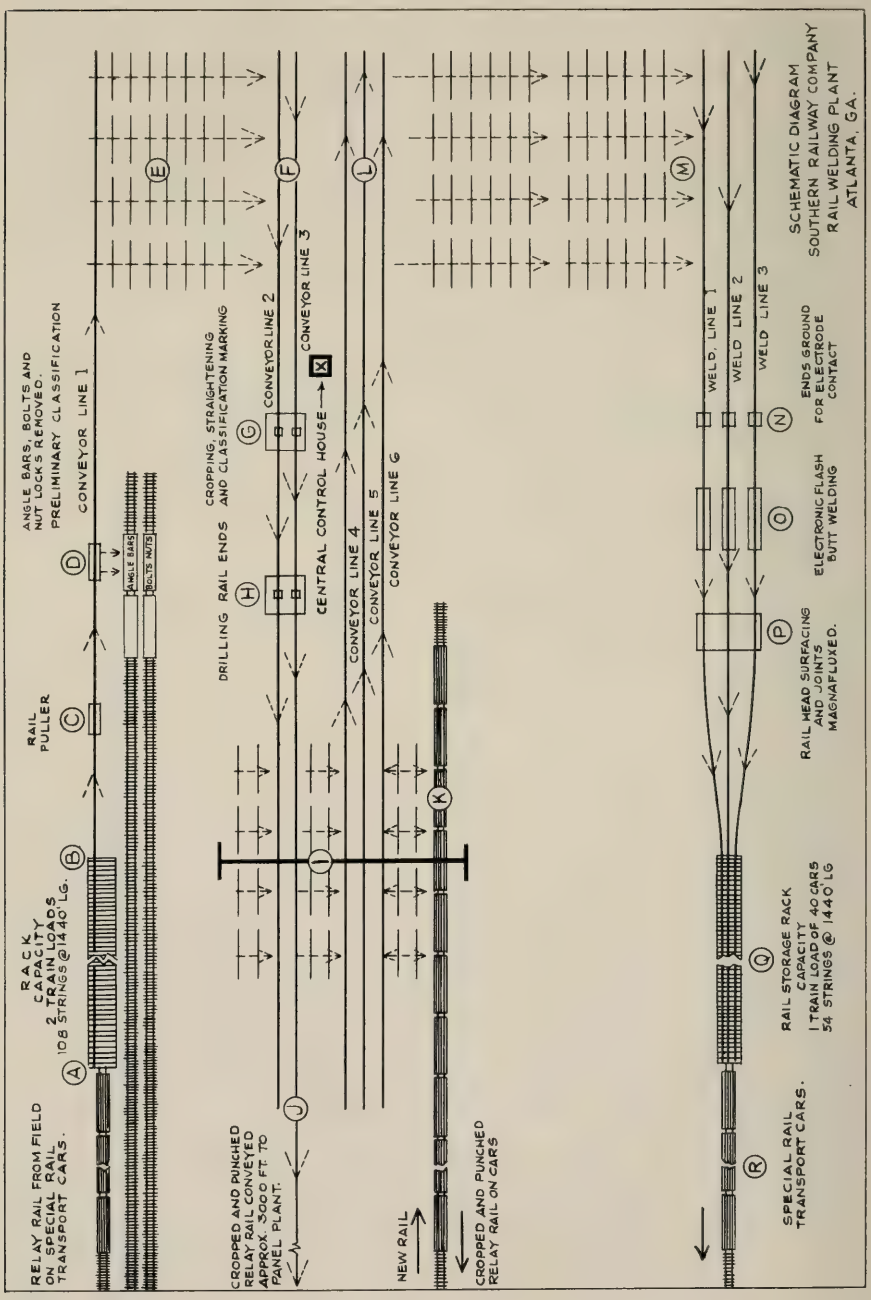
The Southern's extensive continuous welded rail program for both new and relay rail brought about the need for handling large quantities of rail and other track materials with specialized equipment and machinery. In the construction of its large Inman Yard, the handling of the track work was expedited by the design and construction of special equipment for building yard track in panels, and turnouts, at a central location.

RAIL WELDING PLANT

The Southern Railway System centralizes its continuous welded rail operations at its Atlanta plant. All welded rail is transported on special cars, 33 of which make up a train capable of transporting 54 strings of welded rail, each 1440 ft in length. The train is equipped with a device to unload and load continuous welded rail specially adapted to the operation by the Southern Railway.

After the welded new rail or welded relay rail has been installed on line of road, the old rail is loaded in a continuous string by the loading machine directly onto the cars from which the welded rail was removed. The rail is then returned to the rail welding plant where the special rail cars are set in on a track up to Point A, is shown on the accompanying schematic diagram, and unloaded on roller racks where it is stored until ready to be processed through the plant. The roller-rack area has a storage capacity of two trains or 108 strings of rail, each 1440 ft long, and is arranged in such a manner that the rail is stored 12 strings wide and 9 strings high in racks designated as A–B on the diagram.

When any string is ready to be processed, it begins its movement from Point B at the storage rack and is pulled by means of a rail unloading device at Point C onto a single roller conveyor designated as Conveyor Line 1, where it passes through a small shed at Point D. Here the joint bars, bolts, and nut locks are removed from the rail by impact wrenches. These bolts and joint bars are dropped into a hopper conveyor and are conveyed transversely by a continuous conveyor system and automatically loaded into


SCHEMATIC DIAGRAM
SOUTHERN RAILWAY COMPANY
RAIL WELDING PLANT
ATLANTA, GA.
RELAY RAIL FROM FIELD ON SPECIAL RAIL TRANSPORT CARS.
RACK CAPACITY 2 TRAIN LOADS 108 STRINGS @ 1440' LG.
RAIL PULLER
ANGLE BARS, BOLTS AND NUT LOCKS REMOVED.
PRELIMINARY CLASSIFICATION
CONVEYOR LINE 1
ANGLE BARS
BOLTS NUTS
DRILLING RAIL ENDS
CROPPING, STRAIGHTENING AND CLASSIFICATION MARKING
CONVEYOR LINE 2
CONVEYOR LINE 3
CENTRAL CONTROL HOUSE
CONVEYOR LINE 4
CONVEYOR LINE 5
CONVEYOR LINE 6
CROPPED AND PUNCHED RELAY RAIL CONVEYED APPROX. 3000 FT TO PANEL PLANT.
NEW RAIL
CROPPED AND PUNCHED RELAY RAIL ON CARS
SPECIAL RAIL TRANSPORT CARS.
RAIL STORAGE RACK CAPACITY 1 TRAIN LOAD OF 40 CARS 54 STRINGS @ 1440' LG
RAIL HEAD SURFACING AND JOINTS MAGNAFLUXED.
ELECTRONIC FLASH BUTT WELDING
ENDS GROUND FOR ELECTRODE CONTACT
WELD LINE 1
WELD LINE 2
WELD LINE 3
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R

gondola cars. At this point the joint bars are classified, and scrap materials are deposited in another car situated on the opposite side of Conveyor Line 1, also automatically. The loaded cars containing joint bars, bolts, nuts, and scrap are then moved by switch engine either to the track panel plant or to the scrap-disposal area.

Also at Point D the relay rail being handled is given a preliminary classification, and its usefulness as panel track rail or relay welded rail is determined. From Point D the rail continues on Conveyor Line 1 to automatic transverse racks at Point E. From the central control house, "X", this rail may be transferred from Conveyor Line 1 to any of several transverse conveyors automatically and conveyed transversely either to Conveyor Line 2 or Conveyor Line 3 at Point F.

These conveyors are of the single-line, continuous-moving type, and handle individual rails to the cropping and straightening plant at Point G. At this point the rails are straightened and cropped in an automatic process in accordance with the condition of the rail ends. Also, at this point the general use of the rail being processed is determined and one, two, or three spots of green paint are sprayed on the rail ends to indicate classification.

After the rail passes through the cropping and straightening plant on Conveyor Lines 2 and 3 at Point G: if it is to be sent to the track panel plant or shipped out for some purpose on line of road and requires drilling, it passes through the drilling plant at Point H, where it is automatically drilled on both ends. The rail that is drilled and classified to go to the panel track plant passes on down Conveyor Lines 2 and 3, and an overhead magnet crane at Point I picks up this rail automatically, transferring it to a single, continuous-moving roller conveyor at Point J, which carries it a distance of approximately 3000 ft to the track panel plant.

The operation of the transverse conveyor at Point I is also handled through the central control house at "X", which may be set for automatic movement of the rail from either Conveyor Lines 2 or 3 to the transverse conveyors at Point I, or set on Conveyor Lines 4, 5, or 6 to return to the rail welding plant depending on the control sequence set up at the control house.

Relay rail to be welded passes through the drilling plant at Point H where the end rails of each string to be welded are drilled automatically. The rails then pass on to Point I on Conveyor Lines 2 and 3 where they are automatically transferred by the magnet crane at Point I to Conveyor Lines 5 and 6, which are of the continuous-operating roller type. These conveyors carry the rails to Point L where they are automatically transferred on transverse conveyor racks to welding line conveyor Line 3 (continuous-operating roller type) at Point M. The relay rails are then conveyed along this line through the automatic grinder, which grinds the rail ends for proper electrode contact, at Point N, before being conveyed into the electronic, flash, butt welding machine at Point O. After the butt-welding operation the rail continues on the Weld Line 3 conveyor through the quality-control house at Point P, where the grinding of welds and surfacing of rail head are performed and the welds are inspected for any defects. From Point P this rail continues on Weld Line 3 and into the rail storage rack at Point Q, which has a capacity of 54 strings of continuous welded rail, each 1440 ft long. These strings are stored in layers nine strings wide and six strings in depth. The capacity of this storage rack is one train load of 33 cars of welded rail.

From Point R the newly welded rail strings are loaded onto the special cars by the special rail-loading equipment for transport to points on line for relay purposes.

New rail is received and stored in stock piles near the rail welding plant. This rail is loaded by crane on cars in accordance with the number of rails to be welded in one

continuous string, including the drilled rails which are to be welded on each end of the string. These cars are placed on the track under the automatic crane at Point I and on track K. This rail is then moved transversely in automatic operation to continuous-roller Conveyor Line 4 and moved to Point L. Here it is automatically moved on transverse conveyor racks and deposited either on the Weld Line 1 or the Weld Line 2 conveyors, or both, at Point M. From this point the new rail moves in a similar manner as the relay rail is handled on the Weld Line 3 conveyor, that is, first through the automatic grinders for proper electrode contact at Point N; then into the electronic, flash, butt-welding machines at Point O; thence into the quality-control house for the grinding, finishing and testing of welds; thence onto the storage racks at Point Q, the same racks being used either for relay rail or new rail, whichever is being processed; and thence onto the special transport cars for handling on line of road to the point where the new rail will be installed in track.

All of the operations performed at this welding plant are automatically controlled from control house "X", including the sequence of operation of any of the conveyor systems. The complete operation is an ingeneous, ultra-modern application of conveyor systems and automatic controls to the process of fabricating continuous welded rail.

PANEL ASSEMBLY PLANT

General

The plant was built and is operated for the purpose of assembling materials into finished panels of track with non-staggered joints and of conventional lengths. The process used is a "straight-line" operation with many features comparable to those found in the most progressive manufacturing plants. Production is not for inventory or stock, but of the "job" type. Production is initiated by an order for specific quantities with certain specifications (lengths, new or fit materials, etc.). The plant capacity is adequate for all industrial, yard, and branch track construction on the system.

Assembly

The assembly is performed on a continuous conveyor line of parallel drag chains with movement passing fixed work stations. A description of operations at each work station is given below:

Work Station	*Operations*
1	a. Sort scrap and reusable ties. b. Scrap ties chuted to furnace. c. Straighten reusable ties against spacing and pusher attachments on chain.
2	a. Place tie plates on each tie end.
3	a. Place spikes on each tie end. b. Place anchors on end ties of panel.
4 (conveyor stopped)	a. Gage tie plates—two parallel, mechanical, panel-length template-type jigs. b. Pick up two rails simultaneously, move to and place in tie plates, hold for spiking—two parallel, mechanical, clamping-type jigs. c. Place spikes in fixtures on six, twin, air-operated spiking hammers suspended from two parallel monorails, and drive the spikes. Ties are held against rail by vertical, mechanical pistons. d. Drive anchors on rail at end ties of panel with sledge.
5	a. Assemble joint material on leading end of panels. b. Operate transfer bridge for two parallel loading tracks and load cars. Each car has separate power unit, parallel drag-chain conveyors at floor level, and elevating mechanism to lift panels into eight tie storage positions. Cars end-to-end form continuous conveyor.

Material Handling

The material handling of stock to the work stations is mechanical, and some features are automatic or semi-automatic. A description of the handling of each type of material is shown below:

Rail—Supply is from the cropping plant via powered roller conveyor providing longitudinal movement to drag-chain conveyor, providing moving transverse storage at work station 4. Control of both conveyors is at work station 4.

Tie Plates—Supply is from gondola via automated bridge crane and magnet to hopper storage discharging to elevating belt conveyor to work station 2 which has control of the belt conveyor.

Spikes—Supply is from gondola via same automated bridge crane used for tie plates to hopper storage discharging to elevating belt conveyor to work station 3 which has control of the belt conveyor.

Ties—Supply is from gondola via bridge crane with grapples to work station 1. Control is at work station 1.

Bars, Bolts, Nutlocks—Stock stored at work station 5.

PREFABRICATING TURNOUT PLANT

The plant for prefabricating turnouts consists of a concrete bed on which an adjustable switch pattern is positioned for fabricating various turnout sizes from No. 6 to No. 12. This switch pattern incorporates position lugs mechanically adjusted to fit the switch tie spacings of the various-size turnouts. There are also position lugs that mark the exact location for the switch points and the frog. These position lugs are actuated by a hand-thrown lever which sets up all the lugs for the particular size of turnout desired.

The material for the construction of the turnouts is stored within range of an overhead 15-ton crane. Switch ties, rail, frogs, guard rails and switch points are placed on the concrete bed by the use of this crane. The switch plates and tie plates are placed on the ties by hand. The turnout is then constructed by using small power tools. After the turnout is completed it is loaded on two specially designed turnout cars in two separate sections. The special cars are so constructed that the switch end of the turnout up to and including the 9-ft ties are loaded on one car in a flat position and the remainder of the turnout (frog end) is loaded on the second car in an angular position. The floor of the second car is so constructed that after the frog end of the turnout has been loaded it can be rotated to an angle of approximately 50 deg to give proper balance while being handled in revenue trains. The floors of both cars can be elevated and end-tilted so that the turnout can be easily unloaded from one end.

When installing the turnout the cars are so spotted that the switch point end of the turnout is at one extreme end location, the frog end of the turnout being at the opposite extreme end location. The existing track section or the old turnout is then removed by pulling it to one side by a specially equipped bulldozer. After the removal of the existing track section or old turnout, the bulldozer removes the old ballast so that the two portions of the new turnout can be placed at the proper elevation to the adjoining track. Then the two portions of the turnout are unloaded from each end of the two cars and bolted together. New ballast is placed throughout the switch area by the use of trucks and high-lift equipment.

After the new turnout is installed, the old one is lined back on top of the new track by the use of the bulldozer and loaded onto the same cars that carried the new turnout. This old turnout is then returned to the prefabricating plant for rebuilding.

INMAN YARD

The committee also had an opportunity to inspect the Southern's recently completed Inman Yard. Basically, the yard proper receives trains from all directions, classifies in a south to north direction, and dispatches in all directions. Over this whole area there are strung innumerable mercury vapor lights which yield a shadowless yard at night.

The receiving yard, consisting of 16 tracks with an average length of 145 cars each, is built on a 0.2-percent grade down to the scale at the hump. At the beginning of the hump track there is an inert retarder to bunch the cars for ease in cutting them, and at the crest of the hump there is a single truck retarder to slow down cars that are moving too fast.

Next in line is a 105-ft, 400-ton-capacity electronic scale capable of handling 1100 cars each 8 hours. This scale leads to electronically controlled retarders ahead of 65 classification tracks on a 0.1-percent rolling grade and with an average length of 45 cars each. On one side of the classification yard is an ice house for refrigerator cars. The outside track on the other side of the yard connects to the cleanout track and the rip tracks.

The departure yard is made up of 16 tracks with an average length of 150 cars each. Instead of being built in a continuing straight line, the departure yard was placed approximately parallel to the hump track with the minimum distance possible between the two leads, one coming from the classification yard and the other to the departure yard. Between the departure yard and the hump are the cleanout and repair facilities.

To speed the classification of the cars a closed circuit television is used together with a pneumatic tube system for delivering and sending messages to and from the center yard office. In the center yard office all inbound trains are viewed on television, and the car numbers are read into a dictaphone. From this information a list is made and compared with the weight bills which have been delivered to the yard office by the train conductor using the pneumatic tube. Based on this comparison a classification list is made and sent to the hump conductors' office by another pneumatic tube. At the same time the classification list and the weight bills are taken to the scale room. Here the bills are placed in order in a revolving rack subdivided for each classification track. As a train is made up and placed in the departure yard, the weight bills can be picked off the rack in order and sent with the train.

In the hump office the hump conductor, using the classification list, operates a console-type board to line the classification yard switches and begin the electronic calculations for determining the necessary retardation. Opposite the hump office a trainman insures coupling by inserting a fiberboard wedge in the coupler to hold it open. This wedge is inserted by a long-handled air gun.

Another means of increasing efficiency is the use of radio communications. Several wave lengths have been assigned for train and yard use. A great number of hand sets are used which allow communication between the ground, engine cabs, cabooses, and the various yard offices.

Besides classifying, the yard is used as a point for inspection, maintenance, and repair of cars. The inspection begins approximately 20 miles out where approaching trains are scanned by a hot-box detector. The information is transmitted electrically to the yard where it appears graphically in the form of a chart showing all journal-box temperatures. After the train enters the receiving yard, any car suspected of having a hot box is inspected individually. If necessary, the cars are listed to go to the repair facilities.

The next step in the process is the inspection of all cars. To make this inspection, the car inspector rides in a small self-propelled cart developed by the Southern. This

cart, which carries all necessary equipment, travels between tracks. It is guided by the tie ends, thus eliminating the need for steering. The inspector sits in the cart low enough to see the underside of all ordinary freight cars. As he travels along, he opens all journal boxes, marking those needing oil. He also inspects for cracked journals with a sonic device.

Additional inspection is carried on as the cars are brought to the hump. Ahead of the hump conductors' office, fingers are set along both rails to feel for broken flanges. Coupled to these fingers is an automatic paint spray for marking defective wheels. Also, as the cars approach the hump they pass inspection booths placed on either side of the track. These booths allow visual inspection of the complete underside of any car. Also, the operators control a device to oil any journal box which has been so marked by the car inspector.

If a car has been found to need repairs at any one of the inspection points, the hump conductor automatically sends the car to the classification track connecting with the rip tracks.

ONE-SPOT CAR REPAIR SHOP

The one-spot car repair system in use at Inman Yard provides three locations for repairing cars simultaneously, one car at each location; two locations are used for light repairs that can be completed in 30 min to 1 hr, and one location is used for cars requiring heavier repairs. The cars are moved from the inbound leads to the work spot by a mechanical car-pulling system operated by the car repairman at his repair station by push-button control. When the car is spotted in the repair area, the car repairman is fully equipped to make the necessary repairs.

The repair equipment includes three hydraulic stationary jacks, one located between the rails for tank cars and one outside of each rail for raising other types of cars. Jib cranes equipped with electric hoists are used in making truck repairs. Each work area has overhead hose reels containing oxygen and acetylene cutting equipment, and has journal box oil, compressed air and water hoses. Electric welding equipment is readily available on overhead reels. Tool boards are located at each station with the car repairman's tools positioned so that each tool has its proper place on the board and is within easy reach of the repairman.

The store-room area is served by a truck driveway and a spur track with high platforms located at the end of the 150-ft by 100-ft clear span building covering the three car spot repair areas. All material required for repairs is delivered to the work area by a stores attendant equipped with a heavy-duty fork lift truck. Car scrap is placed in a trailer at the truck dock and is removed by a local scrap dealer who provides the trailer for this purpose. All small repair parts are contained in metal containers which may be handled by the fork lift truck. When a part is removed from the container for use on a car, the old one is returned to the same container and eventually returned to the reclamation store house.

The entire area is lighted with fluorescent lighting, and the work area is heated by radiant heat from overhead electric heaters and heat coils provided in the floor. Air-conditioned lunch and welfare rooms are provided in separate buildings adjacent to the car repair building.

There are two inbound service leads for each work spot with a capacity of 12 cars each. Each track is interlocked with power-operated blue flag gates and derails, controlled by the car repairman from his control panel at the work spot. This permits the yard crew to place cars awaiting repairs on one lead while the cars on the other lead are being moved into position for repairs.

Adjacent to the car repair building and opposite the store-room area, a one-spot car-cleaning track is provided to accommodate 20 cars at one time. It consists of a platform at car-floor level and is equipped with incinerator, a trailer to accommodate unburnable refuse, a heavy-duty vacuum cleaner and special equipment for washing out cars. The cleaner and high-pressure hose are easily moved into the box car with a portable overhead conveyor arm. The same protection that the car repair tracks have is provided for the clean-out track, and the cars are moved into position by a mechanical car mover. All controls are interlocked and are operated from a push-button panel at the work spot by the car cleaner.

CONCLUSIONS

The Southern Railway System has undertaken extensive research in work-simplification methods in the maintenance-of-way department and has made remarkable progress in handling track materials with mechanized devices. Programming its repair and renewal work in the track and bridge and building departments with special tools has effected economies in maintenance and material handling. Travel time required for employees to get to and from the point of work has been considerably reduced by providing the men with comfortable, modern, stainless-steel trailers for living quarters.

It is the committee's opinion that the Southern Railway has substantially reduced the costs of maintenance of way work and has provided the men with better tools to do their work with a minimum amount of physical effort.

Report on Assignment 3

Relative Economies to be Derived from Ownership Vs. Rental of Maintenance of Way Work Machinery

Collaborating with Committee 27

E. J. Sierleja (chairman, subcommittee), M. B. Allen, J. L. Cann, J. A. Caywood, W. E. Chapman, S. A. Cooper, P. A. Cosgrove, C. G. Davis, M. H. Dick, W. M. S. Dunn, J. L. Fergus, L. C. Gilbert, R. R. Gunderson, V. C. Hanna, Claude Johnston, H. W. Kellogg, N. W. Kopp, J. S. McBride, H. C. Minter, R. W. Pember, R. R. Pregnall, Jr., D. E. Rudisill, H. W. Seeley, John Stang, A. H. Stimson, W. B. Throckmorton, H. M. Williamson, F. R. Woolford.

Your committee submits the following report as information, with the recommendation that the subject be discontinued.

SCOPE

The scope of this assignment could have been very broad and possibly caused long and unnecessary research into types of rentals or leases which are not and/or will not be used to any great extent. It was determined through a questionnaire directed to a sample of railroads that the primary interest was in a lease with the following general characteristics:

1. The basic lease period is from three to five years.
2. The amount to be paid as rent is a total of the listed purchase price and finance charges.
3. Machinery is not returnable within the basic lease period.
4. The lease is renewable at a reduced amount of rental and/or there is an option to purchase.
5. Maintenance and operation are furnished by the lessee at his cost.
6. Insurance, taxes, etc., are paid by the lessee.

The above-listed characterics indicate that the prime use of leases is as a tool to finance replacement of old machinery or acquisition of new machinery.

This study is limited to leases with the above characteristics. In addition, it is limited within the following areas.

1. The machinery is available in an open market, with either purchase or leasing provisions.
2. The lessor is the organization or person that holds title to the machinery and submits rental bills to the lessee.
3. The lessee is the railroad company.

The questionnaire was forwarded to 23 railroads and replies were received from 16. There were 7 roads which stated that they do not use leases and 9 which do use leases. The responding roads indicated that they have anticipated or realized the following economic advantages and disadvantages.

Advantages of Leasing

1. Release of cash for other higher-return investment.
2. Makes possible the use of cost-cutting equipment even though cash is not available.
3. No increase in funded debt.
4. Tax advantage—faster write-off or depreciation.
5. Tax advantage—expenditure made as an operating expense.
6. Provide hedge against rapid obsolescence.

Disadvantages of Leasing

1. Finance charges incurred in lieu of purchase made with cash.
2. Higher finance charges than if purchased and financed as funded debt.

ANALYSIS

The balance of this report examines in detail the above-listed advantages and disadvantages and develops some additional ones. The source literature used to make this analysis has been compiled into a bibliography which is presented at the end of this report.

Since there is no published literature pertaining to the lease-financing of maintenance of way machinery, this bibliography consists of literature which refers to lease-financing other specific types of machinery or industrial equipment in general.

ADVANTAGES

Release of Cash for Other Higher-Return Investment

Any decision involving the selection of alternate investments requires measurement of rate of return and allocation of cash. Leasing provides additional available cash during the early years of the service life because of less income taxes during those years. If an alternate investment with a higher rate of return is available, this additional or freed capital can be used for this investment which will produce earnings in excess of the financing charges. Tables 1 and 2 illustrate this advantage.

However, it must be pointed out that this advantage does not exist if the lease term is equal to or greater than the existing depreciation term; if the higher-rated investment is not available or is not made; or, if the Internal Revenue Department does not allow the lease payments as operating expenses. This last feature is reviewed later in this report.

TABLE 1—COMPARISON OF CASH FLOW FOR EQUIPMENT VALUED AT $100,000. USUABLE LIFE OF 10 YEARS. NO SCRAP VALUE. $100,000 ANNUAL CASH INCOME. $200,000 CASH ON HAND AT BEGINNING OF FIRST YEAR

Method of Financing	(*a*) *Year*	(*b*) *Cash on hand at beginning of year*	(*c*) *Cash income before d, e, f, g*	(*d*) *Depreciation (non cash expense)*	(*e*) *Rent (cash expense)*	(*f*) *Income tax at 52%*	(*g*) *Purchase payment*	(*h*) *Cash from year's operation (c-e-f-g)*	(*i*) *Cash on hand at end of year (b+h)*	(*j*) *Cash excess or deficiency of rental*
Rental Plan:	1	200,000	100,000		23,097	39,990		36,913	236,913	
	2	236,913	100,000		23,097	39,990		36,913	273,826	
a. Five-year lease with one year renewals at one dollar per year.	3	273,826	100,000		23,097	39,990		36,913	310,739	
	4	310,739	100,000		23,097	39,990		36,913	347,652	
	5	347,652	100,000		23,097	39,990		36,913	384,565	
	6	384,565	100,000		1	51,999		48,000	432,565	
b. Financing rate 5 percent on declining principal.	7	432,565	100,000		1	51,999		48,000	480,565	
	8	480,565	100,000		1	51,999		48,000	528,565	
	9	528,565	100,000		1	51,999		48,000	576,565	
c. Annual payments.	10	576,565	100,000		1	51,999		48,000	624,565	
			1,000,000		115,490	459,945		424,565		
Purchase—Cash:	1	200,000	100,000	10,000		46,800	100,000	—46,800	153,200	83,713
	2	153,200	100,000	10,000		46,800		53,200	206,400	67,426
a. Net 30 days	3	206,400	100,000	10,000		46,800		53,200	259,600	51,139
	4	259,600	100,000	10,000		46,800		53,200	312,800	34,852
b. Depr. method: straight line 10 percent	5	312,800	100,000	10,000		46,800		53,200	366,000	18,565
	6	366,000	100,000	10,000		46,800		53,200	419,200	13,365
	7	419,200	100,000	10,000		46,800		53,200	472,400	8,165
	8	472,400	100,000	10,000		46,800		53,200	525,600	2,965
	9	525,600	100,000	10,000		46,800		53,200	578,800	—2,235
	10	578,800	100,000	10,000		46,800		53,200	632,000	—7,435
			1,000,000	100,000		468,000		432,000		

TABLE 2—PROJECTED EARNINGS ON CASH EXCESS FREED BY RENTAL. REGULAR INVESTMENT OF EACH YEAR'S CASH EXCESS IN A CONTINUING PROJECT EARNING 25%

(1) Year	(2) Freed capital	(3) Freed capital plus cumulative earnings from previous year (Col. 7)	(4) Earnings at 25% on Col. 3 totals	(5) Income taxes at 52% of Col. 4 totals	(6) Earnings after taxes	(7) Cumulative earnings after taxes
1	83713	83713	20928	10883	10045	10045
2	67426	77471	19368	10071	9297	19342
3	51139	70481	17620	9162	8458	27800
4	34852	62652	15663	8145	7518	35318
5	18565	53883	13471	7005	6466	41784
6	13365	55149	13787	7169	6618	48402
7	8165	56567	14142	7354	6788	55190
8	2965	58155	14539	7560	6979	62169
9	—2235	59934	14984	7792	7192	69361
10	—7435	61926	15482	8051	7431	76792
			159984	83192	76792	76792

Makes Possible the Use of Cost-Cutting Equipment Even Though Cash Is Not Available

This advantage is probably the greatest and the most valid of all those reported or considered. This is most evident when limiting this analysis to maintenance of way machinery and the present economic situation of many railroads.

The rapid and radical development of new cost-cutting equipment almost necessitates that a road purchase such equipment However, the cash situation in many cases is not such that these purchases can be made. The leasing of the equipment provides a way to get immediate cost reduction without waiting for available investment capital.

No Increase in Funded Debt

When a decision is made to lease-finance rather than purchase via long-term debt, the lease does not appear as funded debt in the company balance sheet. Credit rating is determined by ratios of debt to equity. By leasing in lieu of increasing long-term debt it would seem that the credit rating would not decrease. However, many lending institutions and regulatory agencies such as the Securities and Exchange Commission are using a ratio in which the fixed charges are defined to include "an appropriate portion of rentals under long-term leases."

This practice of credit rating makes this advantage an illusion.

Tax Advantage—Faster Write-Off or Depreciation and Expenditure Made as an Operating Expense

Examination of the tax column in Table 1 reveals that there is not any long-range tax advantage of leasing vs purchase. In other words the lease does nothing more than postpone taxes. In some special cases there might be a beneficial savings to the lessee on a short-term basis. In this case the lessee should be extremely careful to assure himself that the lease terms are such that it qualifies as a lease and not a conditional sales contract. The Internal Revenue Bureau has made rulings which define bona fide leases and those which they consider conditional sales contracts. Of course, if a lease does not qualify as such, the increased cash flow benefits previously described are not available to the lessee.

Provide Hedge Against Rapid Obsolescence

A lease with a term less than the normal depreciation life makes possible the acceleration of the charging of machinery usage costs against the savings produced by that machinery. In a situation of rapid technical obsolescence, such as in maintenance of way machinery, this shorter term reduces the risk involved in projecting equipment acquisition forecasts over the term involved in purchase and depreciation.

There are some lessors who will convert or replace machinery which is made technically obsolescent. This provision entails certain economic risks to the lessor, and his lease terms can be expected to compensate him for his risks.

Ownership generally tends to make the owner retain machinery after its useful life to avoid capital expenditures, while in contrast, leasing tends to encourage the use of new and modern machinery.

Other Advantages

The lease provides a current entry of an identifiable expense item in the budget and costing system. The management person charged with this cost then has a measure by which he can compare the resultant savings vs. the rental costs. This is not possible in most systems if the cost is handled as depreciation.

Some claim has been made that a net accounting savings is possible when it is not necessary to maintain depreciation records.

DISADVANTAGES

The first disadvantage is the additional cost of finance charges which are not incurred when purchasing with cash. Secondly, the normal lease provides for a minimum of one-half to one percent higher interest than if purchase is made through long-term debt. In some cases this spread can amount to as high as five or six percent.

CONCLUSIONS

It is not possible to state an over-all economic advantage for either rental or ownership. Each of the preceding disadvantages and advantages should be considered and evaluated by the individual railroad, with consideration being given to its own economic situation and the terms of the proposed lease. However, it is believed that the advantage which is most important and which should determine the decision in most cases is that a lease makes possible the use of cost-cutting equipment even though cash is not available.

The type of rental which is considered in this report is one which in effect provides a financing tool for purchase of equipment. Because of this fact and that the available financing charges cover a broad range, the financial department of a railroad should participate in the decision to rent or buy. If a decision is made to rent, then the financial department is in the best position to negotiate for the lowest possible financing charges.

The lease terms determine whether the I.R.B. will allow deductions of the rental payments. If a tax advantage is desired, terms of the proposed lease should be reviewed by the tax department of the railroad to determine whether the lease will be accepted by the I. R. B.

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Report on Assignment 4

Labor Economies to Be Derived from the Use of Modern Equipment, Optimum Treating Programs, and the Most Efficient Chemicals for Control of Vegetation

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Your committee submits the following brief report of progress in the assembly of data pertaining to the above subject.

Questionnaires were sent to 56 railroads, and replies have been received from 28.

Arrangements are being made to collaborate with Committee 1 on its Assignment 11—Chemical Control of Vegetation, Collaborating with Signal Section and Communications Section, AAR. When sufficient replies to the questionnaire have been received, and after conferring with representatives of Committee 1, a progress report will be submitted.

Report on Assignment 5

Labor Economies to Be Effected Through Use of Power Tools and Mechanized Equipment by Bridge and Building Gangs

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Your committee submits the following report of progress in determining the labor economies to be affected through the use of power tools and mechanized equipment by bridge and building gangs. Some interesting and economical new machines have been

developed, and novel and economical adaptations have been made with other machines.

As in last year's report, this report covers only certain machines found to be the most economical in maintenance work, although the tools and equipment described are also economical in construction and rebuilding work.

In connection with the following report, it is suggested that last year's report on this assignment be reviewed.

Pile-Driving Gangs

A combination on-track off-track pile-driving outfit has been developed. It consists of a large truck crane mounted on a specially designed crane carrier. The upper machinery of this combined unit is powered by a gasoline engine with a two-speed transmission. The unit is supplied with a 30-ft boom with additional removable sections for a total length of 50 ft, a high-speed boom hoist with controlled boom lowering, crane lagging for two drums, a third drum attachment, retractable high gantry and safety boom stops.

The machinery deck is a heavy-duty fabricated unit, and the entire assembly, including non-skid walkways, is welded together in rigid alinement for the most severe operating conditions. The counterweight is securely attached to the rear of the machinery deck while operating, and the tail slab can be quickly and easily removed for highway travel. The operator is located at the front right-hand corner of the machinery deck where he has an unobstructed view of work at all times.

The shafts are of heat-treated nickel-chromium steel, turning in ball bearings. Safety boom stops, telescoping pipe, are provided to prevent over-hoisting the boom, and to prevent the boom from going over backward in the event of the failure of a hoisting line or some part of the hoisting tackle. Boom splices are of the pin type for rapid dismantling and assembly.

Air brakes are provided on all wheels. Outriggers and screw jacks, removable, are hydraulically set from the carrier. The inner dual rear wheels are dished to allow bolting on four additional wheels for highway travel.

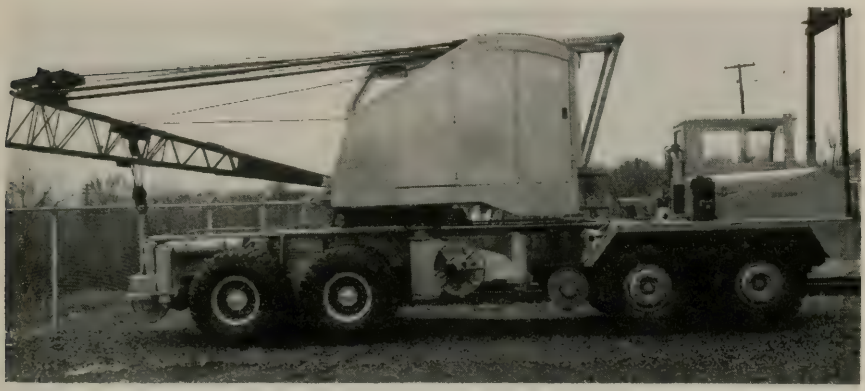
The unit is equipped with a special 20-in track-roller, guide-roller assembly for movement along the track. When in position the track rollers carry 70 percent of the weight of the machine and are locked into position when in service.

The unit has 15 speeds forward and 3 speeds in reverse, actuated by remote-control equipment, as are the accelerator, clutch, and wheel brakes. Steering is by hydraulic power.

The truck crane is combined with specially designed leads and hydraulic bottom brace and is fitted with a diesel hammer designed to reach out 26 ft to drive side-to-side batter piles on a 2½ to 12 maximum slope, suspended from a lifting boom crane. The usual moon beam for side-to-side batter has been replaced by a hydraulically operated parallelogram mechanism. The parallelogram bottom brace eliminates the necessity of blocking up the usual bottom brace while the lead is pulled to one side and pinned to the moon beam. This new bottom brace permits faster operation when changing batter and when folding up out of the way of passing trains. The bottom brace is a 4-bar mechanism activated by one hydraulic power cylinder and is made telescopic by steel tubing.

The pile hammer has a 2800-lb ram, delivering an average striking energy of 16,800 ft-lb per blow and a maximum striking energy of 22,400 ft-lb per blow. The usual length of lead is 55 ft.

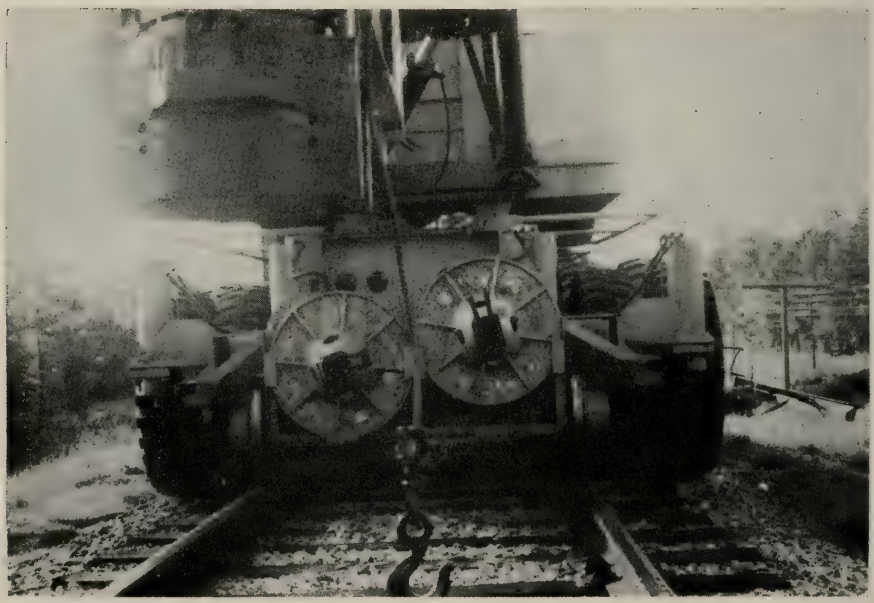
A cost study was made in using one of these machines in driving 370 piles for a trestle. The best driving average per hour on track for this machine was five 45-ft piles. No work trains were involved in connection with the use of this machine, and when



Hoist stripped and ready for highway travel. Two hours time required to strip hoist of leads, boom and hammer and stow same on truck.

Truck for handling leads, boom and hammer assembly on highway.

Hoist on track going to the job with boom and leads in traveling position.



Front of hoist showing carrying position of two of the hydraulic outriggers, close-up of diesel hammer head or anvil and hydraulic cylinder partially extended that controls the parallelogram mechanism. Also shown are the rubber tires of the front end of the bogie in contact with the cross or bridge ties for its only means of locomotion.

Hoist driving pile. Side view of hydraulically operated parallelogram. Also shows how the front pair of wheels of the front bogie are lowered for traction on the ties. This is done mechanically by the operator in the cab.

the pile driving was completed the hammer and leads were removed and the machine was used as a 30-ton hoist for removing the old trestle and placing the new, as a dragline, and for other work usually associated with a truck-mounted crane.

The cost figures showed that a 20 percent greater production was secured with the use of this machine while driving piles compared with a standard pile driver, with the additional advantages that a bridge hoist was available for handling material, etc., and that the cost of work trains was saved.

Torque-Control Wrench

This wrench shuts off when the desired torque is reached. When used in applying high-tensile bolts in place of rivets, a considerable saving is effected. Cost figures indicate a saving of 5 cents for each bolt used in place of a rivet. Two men can place 800 bolts in the same time that three men can drive 400 rivets. In a typical day one gang placed 675 bolts, even though hampered by having to move scaffolding.

Power-Driven 12- or 14-inch Pile Augers

These augers facilitate driving piles that are too long to fit under the hammer, or when hard driving is encountered, with consequent savings in time of some 20 percent.

12½- and 15-Ton Truck-Mounted Hoists

These heavy-duty machines are equipped with clamshell bucket and backhoe for excavating and backfilling structures, dismantling trestles replaced by fills, excavating drainage ditches, loading and unloading material, installing culvert pipe, handling aggregates to mixer or storage bins, erecting and dismantling steel structures, and driving rail piles in jetties and for platforms. They are used also in removing and replacing ballast on bridges and trestles.

Being large machines, one unit is usually assigned to two or more divisions, and their work is closely planned and supervised to keep them busy all the time to produce their potential savings.

Power Bridge Hoist

A test was made on one road in connection with decking a trestle, using two bridge gangs of equal size, one equipped with a power hoist and one equipped with a hand-operated derrick. The work with the power hoist was accomplished four times as fast and efficient as the manual operation.

Bridge Greasing Equipment

Further reports of greater production with this equipment have been received. For example, one road reports a 75 percent reduction in the cost of greasing steel bridges as compared to old methods of painting.

Mechanization of Bridge and Building Tunnel Gangs

An assembly-line arrangement of equipment is being used in replacing timber lining with concrete, and for relining old concrete or rock tunnels under heavy traffic.

The equipment consists of a heavy-duty truck-mounted hoist for handling materials, special aggregate bins on flat cars, covered cement hoppers, large-batch mixers, a pump-crete machine of sufficient capacity, and preshaped metal forms.

The use of this equipment has increased production materially, reduced cost and traffic delay.

On-Track Off-Track Trucks with Retractable Rail Wheels

These trucks for transporting men and materials have shown considerable savings over the use of standard trucks.

While not strictly within the scope of this assignment, but lending itself to more and better mechanization, is the setting up of standards for trestles and other structures incorporating the use of prestressed concrete and other permanent-type materials so that future maintenance can be held to a minimum. The first cost of the permanent type of structures is not much higher, if designed correctly, than comparable structures in timber.

It is recommended that all bridge equipment be of the on-track off-track type for greater mobility, maneuverability and savings.

Report on Assignment 6

Relative Economies to Be Derived Through the Use of Tie Pads in Various Locations and Under Varying Circumstances

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Your committee submits the following report of progress in securing information pertaining to the use of tie pads in various locations and under varying circumstances with the resultant economies.

Twenty-five roads of the 47 to which questionnaires were forwarded advised as to

their use of tie pads and the economies estimated or anticipated. No factual savings data from records are available. Applications of tie pads were made by the replying railroads at selected locations for study and evaluation.

Turnouts

Four railroads are using laminated self-sealing tie pads on switch ties. One has no record and made no comments. Two anticipate that switch-tie life will be extended. One estimates that switch-tie life will be extended 20 percent.

Insulated Joints

Thirteen railroads are using laminated self-sealing pads and rubber tie pads at insulated joints. Of the four using rubber pads, two estimate an extended tie life of 10 to 20 percent, and two anticipate an indefinite extended tie life. Of the nine using laminated self-sealing pads, one anticipates no economies or extended tie life, four anticipate that tie life will be extended, and four estimate that tie and insulation life will be extended from 10 to 50 percent.

Open-Deck Bridges

Nineteen railroads are using laminated self-sealing tie pads and rubber tie pads on open-deck bridges. One using rubber pads estimates that the life of bridge ties will be extended 10 percent. Of the 18 using laminated self-sealing pads, five advised that the installation was made too recently to evaluate results, seven anticipate an extended life of bridge ties, and six estimate an extended bridge tie life of 10 to 50 percent.

Railroad Crossings

Nine railroads are using laminated tie pads, or laminated self-sealing tie pads and/or rubber tie pads at railroad crossings. One using laminated pads estimates an extended life of crossing ties of 20 percent. Three using both laminated self-sealing pads and rubber pads anticipate an extended life of crossing ties and crossing frogs with reduced frog maintenance with rubber pads, but a minimum extended life of crossing ties only with laminated self-sealing pads. Of the five using rubber pads, one made the installation too recently to evaluate results; one anticipates an extended crossing-tie life; one estimates a 10 percent extended crossing-tie life; one estimates a 10 to 25 percent extended crossing-tie life, with estimated reduced crossing frog maintenance of 15 to 20 percent; and one estimate a 10 to 20 percent extended crossing-tie life with 50 to 100 percent extended crossing-frog life.

Public Highway Crossings and Paved Areas in Streets

Eleven railroads are using laminated self-sealing tie pads and rubber tie pads in these locations. One using rubber pads estimates a 10 percent extended life of ties. Of the 10 using laminated self-sealing pads, four advised that the installation was made too recently to evaluate results, three anticipate extended tie life, and three estimate a 15 to 40 percent extended tie life.

Tunnels

Two railroads are using tie pads in tunnels. One using rubber pads estimate a 10 percent extended life of ties, and one using laminated self-sealing pads anticipates extended tie life.

Blow-Sand Areas

Two railroads are using laminated self-sealing pads in these areas and are extending tie life 22 percent.

Curves

Two railroads are using tie pads on curves. One using rubber pads on 6-deg and over curves estimates an extended tie life of 10 percent, and one using laminated self-sealing pads on 2-deg and over curves estimates an extended tie life of 33 to 100 percent.

The laminated pads and the laminated self-sealing pads were produced by eight manufacturers and the rubber pads by one manufacturer. The laminated pads varied from 3 ply to 21 ply, the 3-ply and 5-ply being most generally used.

Two railroads advised that they had made no application of tie pads, and three reported that their experimental application had been made too recently to evaluate results.

Report on Assignment 7

The Specific and Ultimate Improvements in Various Types of Track Maintenance Equipment that Would Provide the Greatest Economies in Maintenance Practices, and How These Potential Economies Would Compare with Present Costs

Collaborating with Committee 27

P. A. Cosgrove (chairman, subcommittee), Lem Adams, L. A. Loggins, J. E. Eisemann, L. C. Gilbert, R. M. Bailey, V. A. Barnhart, Jr., J. A. Caywood, A. B. Chaney, B. S. Converse, M. H. Dick, W. M. S. Dunn, R. R. Gunderson, W. W. Hay, W. H. Hoar, R. H. Jordan, T. L. Kanan, H. W. Kellogg, J. M. Lowry, R. L. Mays, H. C. Minteer, R. R. Pregnall, Jr., R. W. Preisendefer, M. S. Reid, E. J. Sierleja, John Stang, A. H. Stimson, J. T. Sullivan, H. J. Weccheider.

This is a final report, submitted as information. A previous report on this subject was submitted by this committee in 1959 and may be found in the Proceedings, Vol. 60, pages 411 to 413.

Twenty-five railroads replied to a questionnaire sent to 40 railroads requesting recommendations covering improvements in track maintenance equipment which would provide economies in maintenance practices.

Listed below are the improvements recommended:

Spike-Setting Machine

a. Improve mechanized spike drivers to make them fully automatic, from initially placing spikes in tie plate holes to setting and driving them. No estimate of savings was given.

b. Use a feeding device to feed spikes to the spike driver that will permit driving spikes without setting them. Savings of 50 percent are estimated.

Mechanical Tampers

a. Refine mechanical tampers to accomplish better tamping of turnouts, possibly using a monorail tamper with tamping bars that can be moved horizontally to tamp between rails in switches. No estimate of savings was given.

b. Develop an off-track multiple tamper with the tamping blades operated from a narrow-gage crawler-type or rubber-tired power unit, which would be useful for smoothing and tamping low joints and would permit quick movement on and off the track. No estimate of savings.

Power Jacks

a. Substitute tamping power jacks for hand jacks. Savings of 20 percent are estimated.

Tie-Plug Applicator

a. For use in rail-laying operations, develop a machine for filling spike holes in ties with plastic or other preservative substance that will harden. It is estimated that four laborers daily can be eliminated.

b. Use properly mixed chemicals providing a quick-setting preservative material to inject into spike holes that would adhere to the tie and the spike. No estimate of savings.

Tie Remover and Inserter

a. Improvement needed in this machine to speed up tie removal and avoid disturbing line and surface of track. Allow tamping equipment to tamp new tie as soon as placed. No estimate of savings.

b. Develop tie-inserting machine that will pull out old tie and insert new one without necessity of tamping. No estimate of savings.

Tie Car

a. A self-contained tie unloading car. Annual savings estimated to be $25,000.

Brush Cutter

a. Manufacture a double, folding-wing brush cutter or mowing machine to cut rough right-of-way in one pass at 4 to 5 mph, cutting a 15-ft swath on both sides. It is estimated that 30 man-hours per mile can be saved.

b. Develop a rotary-head, telescopic-boom brush cutter to operate from a rail highway truck which could cut from the rails or from the side of the right-of-way. Could replace 12 to 15 men cutting by hand.

Tie Saw

a. Provide a ballast remover for the tie saw which could save approximately $700 monthly.

b. Develop combination machine designed to remove ballast and cut tie in two places on inside of track in one operation. This could save four men per day.

Rail Track Drill

a. Develop a multiple-rail track drill for drilling rail ends. Savings of 50 percent are estimated.

Earth-Handling Machine

a. Develop a ditcher-loader, similar to the force-feed-type yard cleaners but with narrow gage to permit cleaning narrow cuts and capable of loading dry or wet earth into trucks or track-mounted air-dump cars. Greater efficiency should result.

Set-Offs

a. A set-off which is made an integral part of an on-track machine. After the set-off is positioned, the machine could be run off. Savings of $1200 per year are estimated.

Tie Borer

a. Devise a tie borer that can bore two holes at once and thereby eliminate the need for two machines. Two men can be eliminated.

Combination Machines

a. Develop one machine that can correctly gage and fully spike rail in rail relay work. Savings of six laborers per day are possible.

Hack Saw

a. Develop a portable power hack saw designed to cut drift bolts between caps and piling in bridge work, operated either electrically or pneumatically. Savings of 15 to 30 min per bolt are estimated.

CONCLUSION

Equipping many efficient maintenance machines now available with both rubber tires and flanged wheels would not only increase their track maneuverability, but would also improve traveling. In these competitive times, it is essential that train delays be held to a minimum; consequently, roadway maintenance equipment will of necessity have to possess dual off-on-track features, where such is possible.

Little has been accomplished as yet in the direction of full automation insofar as railroad maintenance equipment is concerned. The development of improvements in equipment and reducing the cost of work is our immediate and most important challenge. We must follow the trend of automation as other industries have successfully done.

Report on Assignment 9

Relation Between the Nature of Traffic and the Interval Between Out-Of-Face Resurfacing of Tracks of Relatively Similar Characteristics

R. W. Pember (chairman, subcommittee), A. D. Alderson, M. B. Allen, R. M. Bailey, E. J. Brown, J. L. Cann, J. A. Caywood, A. B. Chaney, B. S. Converse, L. E. Donovan, J. L. Fergus, W. W. Hay, W. H. Hoar, E. Q. Johnson, Claude Johnston, R. H. Jordan, T. L. Kanan, N. W. Kopp, J. M. Lowry, R. L. Mays, J. S. McBride, R. W. Preisendefer, M. S. Reid, D. E. Rudisill, H. W. Seeley, R. G. Simmons, J. T. Sullivan, F. R. Woolford.

This is a final report, presented as information. This subject has been previously reported on, as indicated in the Proceedings, Vol. 60, 1959, page 416.

Gross tons of traffic moved is not a controlling factor in determining the interval between out-of-face resurfacing. This lack of relationship between traffic and the out-of-face resurfacing cycle was developed from replies to a questionnaire sent to 56 railroads. A total of 26 railroads replied to the questionnaire. Six did not complete it.

The railroads were asked to report gross tons of traffic handled and the out-of-face surfacing cycle in years for a selected typical territory (giving location) based on weights of rail varying from lighter than 100-lb section to heavier than 132-lb section. Forty-three combinations of rail weights, out-of-face resurfacing cycle and gross tons carried were reported by the 20 respondents.

The 20 railroads responding to the survey reported operations in 22 states, which included all regions of the United States except the far West, and Canada. This study showed that the out-of-face surfacing cycle does not vary to any appreciable extent among the geographical locations reported.

A summary of the replies received show that of 43 combinations reported, 31 were scheduled in either 4- or 5-year periods, with the remaining 12 ranging from 3 to 10 years.

The various combinations of gross tons, out-of-face surfacing cycles and rail weights reported are shown in tabular form below:

Cycle in Years	*Million Gross Tons*	*Number of Reports*	*Rail Section Lb*
3	16.3–29.1	3	+132
3	12.0	1	131–132
3	12.0–29.1	4	All Sections
4	23.0	1	+132
4	14.0–46.0	6	131–132
4	6.0–10.0	4	100
4	3.0–10.0	4	—100
4	3.0–46.0	15	All Sections
5	10.7–22.8	5	131–132
5	7.5–15.5	8	100
5	1.9– 4.7	3	—100
5	1.2–22.8	16	All Sections
6	12.0	1	131–132
6	17.3	1	100
6	2.5	1	—100
6	2.5–12.0	3	All Sections
7	17.5	1	100
8	9.0	1	100
8	8.0	1	—100
8	8.0– 9.0	2	All Sections
9	1.3	1	—100
10	2.5	1	—100

(+) Indicates heavier than rail section shown.
(—) Indicates lighter than rail section shown.

From the total combinations reported, 72 percent were in the 4- or 5-year out-of-face resurfacing cycle for all rail sections and for both heavy and light tonnage.

One respondent reported that "subgrade conditions, and age and condition of rail have more effect on the out-of-face resurfacing cycle than gross tons of traffic," while another reported that "general roadbed condition affected the out-of-face resurfacing cycle."

CONCLUSION

From the replies received it may be concluded that when out-of-face resurfacing is programmed on a cycle basis, such factors as tie renewals, rail weight and roadbed conditions are considered as the controlling factors in obtaining the optimum requirements for maintenance rather than the highly variable factor of traffic.

It is recommended that the subject be discontinued.

Report on Committee 8—Masonry

E. A. McLeod, *Chairman,*

D. H. Dowe,
Vice Chairman,
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Lyle Bristow
M. W. Bruns
A. W. Carlson
A. E. Cawood
Maurice Coburn (E)
G. W. Cooke
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H. M. Dalziel
G. H. Dayett
G. H. Dayett, Jr.
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W. J. Eney
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E. W. Kieckers
R. J. Klueh
A. P. Kouba
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E. F. Manley
L. M. Morris
L. H. Needham
L. P. Nicholson
R. F. Noll
M. S. Norris
R. E. Paulson
R. B. Peck
J. E. Peterson
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C. B. Porter
W. H. Robertson
R. I. Rollings
J. H. Sawyer, Jr.
C. P. Schantz
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Anton Tedesko
R. A. Ullery
L. E. Vandegrift
Neil Van Eenam
K. J. Wagoner
J. W. Weber
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D. V. Wigal
J. R. Williams
W. R. Wilson
S. G. Wintoniak
G. A. Wolf
E. P. Wright
Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   See report on Assignment 2.

2. Design of masonry structures, collaborating with Committees 1, 5, 6, 7, 15, 28, 29 and 30.

   Progress report, including recommended revisions of, and additions to, material now in the Manual ..... page 462

3. Foundations and earth pressures, collaborating with Committees 1, 6, 7, 15 and 30.

   Crib wall specifications are being reviewed. Those for reinforced concrete and for metal cribbing are essentially complete.

5. Tunnel linings: Design, construction and maintenance, collaborating with Committees 1, 5, 17, 28 and 29.

   Progress report, submitted as information ..... page .465

6. Prestressed concrete for railway structures, collaborating with Committee 6.

   Progress report, including proposed specifications submitted as information . page 466

7. Quality of concrete and mortars, collaborating with Committee 6.

   Part 1 of Chapter 8 is being reviewed and some revisions will be proposed. One proposal will be that for air-entrained concrete the required air content will increase as aggregate size decreases.

10. Methods of construction with precast-concrete structural members, collaborating with Committee 6.

    A report on methods of construction has been prepared, but additional time is required to consider suggestions received from the collaborating committee.

THE COMMITTEE ON MASONRY,
E. A. MCLEOD, *Chairman.*

AREA Bulletin 554, December 1959.

Report on Assignment 2

Design of Masonry Structures

Collaborating with Committees 1, 5, 6, 7, 15, 28, 29 and 30

J. U. Estes (chairman, subcommittee), E. J. Daily, H. M. Dalziel, N. O. Geuder, Sr., F. A. Kempe, Jr., A. N. Laird, R. E. Paulson, J. H. Shieber, A. Tedesko, L. E. Vandegrift, D. V. Wigal.

Your committee last year presented as information a draft of Specifications for Design and Construction of Reinforced Concrete Trestles for Railway Loading (Proceedings, Vol. 60, pages 474–488). These specifications, with the following revisions, are now recommended for adoption to replace material withdrawn from Part 9 of Manual Chapter 8.

Under Sec. A, Art. 2. Scope, add "These specifications apply to tangent track only. For track on curves other applicable forces shall be added."

Under Sec. B, Art. 3. Design Loads, delete item d. Centrifugal force, and reletter following present items e and f as d and e, respectively.

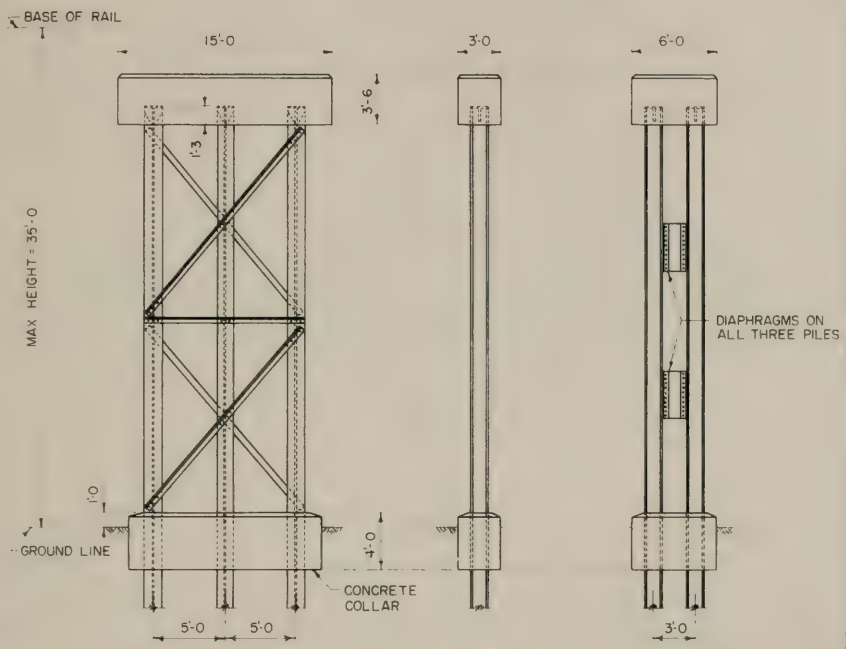
In Sec. B, delete Art. 7. Centrifugal Force. Renumber following present Arts. 8 and 9 as 7 and 8, respectively.

In Fig. 10, change "Pile Cap Detail" to "Steel Bearing Cap Detail" and add under Notes, "The use of steel bearing cap is optional with the engineer." (Revised Fig. 10 presented herewith).

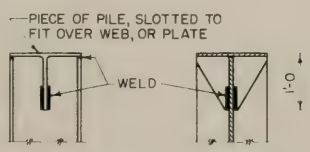
In Fig. 11, change "#2 Ties @ 8″ Centers" to "#2 Square Spirals @ 8″ Pitch", and "#2 Ties @ 2″ Centers" to "#2 Square Spirals @ 2″ Pitch." (Revised Fig. 11 presented herewith).

FIG. 10
AMERICAN RAILWAY ENGINEERING ASSOCIATION
CONCRETE RAILWAY TRESTLE

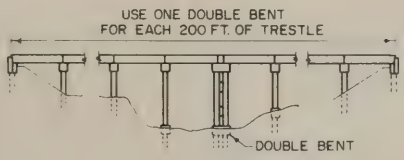
STEEL H-PILE BENT



ELEVATION 3 PILE BENT 6 PILE BENT



STEEL BEARING CAP DETAIL



NOTES

THE USE OF STEEL BEARING CAP IS OPTIONAL WITH THE ENGINEER.

IF BASE OF RAIL TO GROUND LINE IS 16'-0 OR LESS, USE 14BP117 WITHOUT TRANSVERSE BRACING AND COLLAR OR 14BP102 WITH BRACING AND COLLAR

FOR BASE OF RAIL TO GROUND LINE 35'-0, USE 14BP117 WITH BRACING AND COLLAR.

FOR BASE OF RAIL TO GROUND LINE LESS THAN 21'-0, USE ONE PANEL TRANSVERSE BRACING. FOR BASE OF RAIL TO GROUND LINE GREATER THAN 21'-0, USE TWO PANEL TRANSVERSE BRACING.

USE ∟ 5 x 3 x $\frac{3}{8}$ OR 8 ⊔ 18.75 FOR TRANSVERSE BRACING.

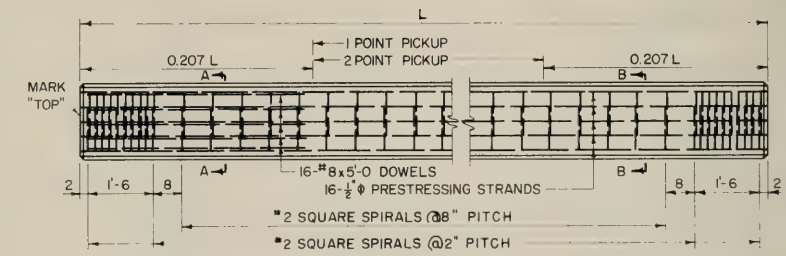
USE $\frac{7}{8}$" HIGH STRENGTH BOLTS WITH HEAVY NUTS CONFORMING TO ASTM DESIGNATION A325 OR $\frac{1}{4}$" FILLET WELDS FOR ALL BRACING CONNECTIONS.

CONCRETE CAP AND COLLAR DETAILS SIMILAR TO FIGS. 3 AND 5

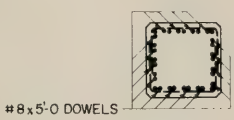
THREE PILE BENTS DESIGNED FOR 10% OF THE SPECIFIED LONGITUDINAL FORCE FOR THE TWO ADJACENT SPANS AS REQUIRED IN PART 2-C, CHAPTER 8.

FIG. 11
AMERICAN RAILWAY ENGINEERING ASSOCIATION
CONCRETE RAILWAY TRESTLE

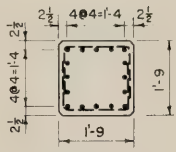
21 INCH PRESTRESSED CONCRETE PILE



ELEVATION



SECTION AA



SECTION BB

NOTES

ALL PRESTRESSING STRANDS SHALL BE ½Φ, 7 WIRE UNCOATED, STRESS-RELIEVED, MEETING THE REQUIREMENTS OF ASTM DESIGNATION A416, WITH A MINIMUM BREAKING STRENGTH OF 36,000 LB PER STRAND.
INITIAL PRESTRESS SHALL BE 27,000 LB PER STRAND.
DOWELS SHALL BE INTERMEDIATE GRADE DEFORMED BARS MEETING THE REQUIREMENTS OF ASTM DESIGNATIONS A15 AND A305.
TIES SHALL BE INTERMEDIATE GRADE BARS MEETING THE REQUIREMENTS OF ASTM DESIGNATION A15.
ULTIMATE COMPRESSIVE STRENGTH OF CONCRETE SHALL BE NOT LESS THAN 6,000 PSI IN 28 DAYS.
CHAMFER ALL EDGES 1".
MAXIMUM LENGTH OF PILE = 50' FOR NO TENSION IN CONCRETE DUE TO HANDLING OR 66' FOR CRACKING MOMENT DUE TO HANDLING. (CRITICAL HANDLING LOAD IS ONE POINT PICKUP WITH 25% IMPACT)
DOWELS PROVIDED IN TOP OF PILE MAY BE USED FOR ANCHORAGE INTO CAPS AS SHOWN ON FIGURE 5 OR FOR SPLICING ON AN ADDITIONAL LENGTH.

Your committee also submits the following recommendations with respect to the specifications for reinforced concrete box culverts, Part 16, Chapter 8:
Pages 8–16–1 to 8–16–10, incl.

SPECIFICATIONS FOR DESIGN AND CONSTRUCTION OF REINFORCED CONCRETE BOX CULVERTS

Reapprove with the following revisions:

On page 8–16–2, add between the present two sentences of the second paragraph under Art. 4. Dead Load, the following sentence: "A lower minimum coefficient may be used if actual conditions justify."

Add to the last sentence of the second paragraph under Art. 5. Live Load: "or lower if actual conditions justify."

Your committee is currently reviewing the specifications for rigid-frame concrete bridges.

Report on Assignment 5

Tunnel Linings: Design, Construction and Maintenance

Collaborating with Committees 1, 5, 17, 28 and 29

G. H. Dayett, Jr. (chairman, subcommittee), A. W. Carlson, R. J. Klueh, L. H. Needham, C. B. Porter, D. H. Shoemaker.

Your committee submits as information the following report on leakage in tunnels.

Leakage in Tunnels and Methods of Correction

General

Water leakage occurs in all types of tunnels. It is one of the most aggravating and difficult problems, detrimental to tunnel linings and contributing to muddy track.

Water leaks usually occur near the portals or where the depth of cover is less than 150 ft. Underground streams or springs may contribute to leakage at any distance from the portal and, in some cases, water following an impervious strata of material may seep out anywhere in the tunnel.

Leaks generally occur at construction joints, cracks that have developed in the lining, honeycombed sections of concrete, and joints of brick or stone lining. Seepage in brick-lined tunnels may cover a more general area than in concrete-lined tunnels due to the type of construction.

Weep holes often fail because of their small diameter or their being blocked by mineral deposits or talus piling up back of the wall. This dams up the water back of the lining, which is relieved by the development of seepage and leaks through the tunnel lining.

Old shafts used in construction may be a source of water.

Correction

For masonry-lined tunnels it is best to bring the water through proper drains into the ditch rather than try to seal the water back of the tunnel lining. Attempts should be made to open existing weep holes and drains; however, where this is not feasible new weep holes and drains should be made. To determine the proper locations for drains holes should be drilled through the tunnel lining at the wet areas to tap the water. Many of the holes will be dry; however, the wet ones found will make the procedure

well worth while. Holes that are dry, but look as though they should drain, can sometimes be opened by air pressure.

The holes should be drilled as near the ditch line as practical, depending of course, on the height of the seepage points, and spaced approximately 10 ft apart, or as judgment indicates. Holes that drain water and are located not over 4 ft above the top of rail should be enlarged a minimum of 3 in, preferably with soil pipe grouted in place with the exposed end extending beyond the inner face of the lining. When holes are drilled higher than 4 ft above the top of rail, consideration should be given to cutting a recessed drain in the tunnel lining and draining the water out near the ditch line. The higher the drilled hole, the more important it is to cut a drain. This is on account of ice formations in winter and the water wetting the face of the tunnel wall at other times, causing deterioration.

Construction joints or cracks where seepage is light may be sealed by chipping the crack in the form of a "V" and caulking with oakum or lead wool, then covering with gunite. These joints and cracks can also be repaired as shown in Fig. 1, page 8–13–3 of the Manual.

Where seepage in joints or cracks is too great to seal, or a definite leak occurs, water should be carried in a drain to the ditch line. A series of holes should be drilled in the drain channel through the tunnel lining to offer an easy path for escape of water. The face of the drain may be of brick or shotcrete.

The use of pressure grout back of the tunnel lining may seal some areas that are wet or possibly drive the water to a point of concentration, where a drain may be cut. Pressure grout applied to the lining may fill internal voids in porous concrete or fill channels in brick lining. However, deteriorated concrete or brick should be removed and replaced. The success of grouting is problematical and must often be used in conjunction with other remedies.

In brick-lined tunnels the seepage of water in a straight horizontal line, especially in the quarters of the arch, indicates that the arch may be cracked and other repairs may be needed.

Very often, leaks around the portals are due to poor drainage over the portal. This may be due to clogged portal drains and/or weathered material forming a catch basin over the portal. Generally it is best to open portal drains, clear drainage ditches above the portal and consider a concrete apron in connection with any remedies that may be taken inside the tunnel.

At best the correction of water leaks is a difficult and frustrating task. The success of any one method is problematical, and there must be used generous portions of trial, error and judgment.

Report on Assignment 6

Prestressed Concrete for Railway Structures

Collaborating with Committee 6

D. H. Dowe (chairman, subcommittee), W. J. Eney, H. J. Engel, R. W. Gilmore, E. W. Kieckers, L. P. Nicholson, J. E. Peterson, R. I. Rollings, C. P. Schantz, J. R. Williams, W. R. Wilson, G. A. Wolf.

Your committee presents as information a tentative draft of Specifications for Design, Materials and Construction of Prestressed Concrete Structures, and requests comment and criticisms thereon, with the thought of presenting them next year for adoption and publication as Part 17 of Chapter 8 in the Manual.

SPECIFICATIONS FOR DESIGN, MATERIALS AND CONSTRUCTION OF PRESTRESSED CONCRETE STRUCTURES

Design Specifications

A. GENERAL

1. Scope

These specifications cover the design of prestressed concrete members of railway structures supporting tracks. They are intended only for use in the design of simple-span structures.

2. Highway Bridges

Unless otherwise specified by highway authority, all highway bridges to be constructed of prestressed concrete shall be designed in accordance with the latest AASHO Specifications for Prestressed Concrete.

3. Buildings

Unless otherwise specified by city ordinance or state code, all railway buildings to be constructed of prestressed concrete shall be designed in accordance with the latest report of ACI–ASCE Joint Committee 323, "Tentative Recommendations for Prestressed Concrete."

B. GENERAL CONSIDERATIONS

1. Purpose

The purpose of design is to define a structure that can be constructed economically, that will perform satisfactorily under service conditions, and will have an adequate ultimate load capacity.

2. Mode of Failure

Ultimate static strength shall be governed by elongation of the prestressing steel rather than by shear, bond or concrete compression. Due consideration shall also be given to the possibility of failure under repetitive loads.

3. Design Method

Design shall be based on the elastic theory with internal stresses limited to recommended values. The ultimate-strength theory shall be applied to insure that ultimate capacity is provided for the specified load factor.

4. Design Loads

The design loads as specified in the specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter, shall be used where applicable.

C. SPECIAL CONSIDERATIONS

1. Loading Conditions

Consideration shall be given to all critical loading conditions in design, including those that occur during fabrication, handling, transportation, erection and construction.

2. Deflections

Camber and deflection may be design limitations and shall be investigated for both short- and long-time effects.

3. Length Changes

Length changes of concrete due to prestress and other causes shall be investigated for both short- and long-time effects.

4. Buckling

General buckling due to prestressing will occur only over the length between points of contact of the prestressing steel with the concrete. General buckling of an entire member or local buckling of thin webs and flanges under external loads may occur in prestressed concrete and shall be provided for in design.

D. ASSUMPTIONS

1. Basic Assumptions

The following assumptions shall be made for design purposes:

a. Strains vary linearly over the depth of the member throughout the entire load range.

b. Before cracking, stress is linearly proportional to strain.

c. After cracking, tension in the concrete is neglected.

2. Modulus of Elasticity

When accurate values for modulus of elasticity are not available, the following values shall be used as a guide:

a. Flexural modulus of elasticity of concrete E_c, in psi, shall be assumed to be 1,800,000 plus 500 times the cylinder strength at the age considered. Actual values may vary as much as 25 percent from those given by the foregoing expression. This expression is not applicable to lightweight concrete, for which E_c shall be determined by test.

d. Modulus of elasticity of steel in psi shall be assumed to be 29,000,000 for cold-drawn wire, 27,500,000 for 7-wire strand, 25,000,000 for strand with more than 7 wires, and 27,000,000 for alloy-steel bars.

3. Deflections

Deflection or camber under short-time loading shall be computed using values of E_c as specified in Sec. D, Art. 2.

Deflection associated with dead load, prestress, and live loads sustained for a long time shall be computed on the assumption that the corresponding concrete strains are increased as a result of creep. The increase in strain shall be assumed to vary from 100 percent of the elastic strain in very humid atmosphere to 300 percent of the elastic strain in very dry atmosphere. These values shall not pertain to concrete made with lightweight aggregate.

E. LOADING STAGES

1. Loading

Loading stages listed in the following Articles shall be investigated. Stages listed are those that normally affect the design.

2. Initial Prestress

Prestressing forces are applied in prearranged sequence and sometimes in stages. If prestressing forces are not completely counteracted by the effect of the dead load of the

member, or if the stressing operation is accompanied by temporary eccentricities, concrete stresses shall be investigated.

3. Initial Prestress Plus Dead Load of Member

For determination of concrete stresses at this stage, losses in prestress shall be considered those which occur during and immediately after transfer of prestress.

4. Transportation and Erection Stresses

Support conditions for precast members during transportation and erection may differ from those during service loads. Handling stresses shall be included together with prestress and dead load. Losses in prestress up to time of handling shall be considered.

5. Design Load

This stage shall include stress due to effective prestress after losses, dead loads, maximum specified live load, and impact.

6. Cracking Load

Members shall be designed so that the extreme fiber flexural tensile stresses under the effect of relaxed prestress, design dead load, live load and impact shall be zero, or compressive.

Cracking will be permitted for an occasional live load of temporary duration. Elastic recovery shall be fully assured from such an overload.

7. Ultimate Load

Ultimate load shall be considered that load which, applied statically in a single application, causes failure. Such a large load is used as a measure of safety.

F. LOAD FACTORS

1. General

A load factor shall be considered a multiple of the design loads used to insure safety of the structure.

2. Ultimate Load Factors

The ultimate load capacity shall be computed, since stresses are not linearly proportional to external forces and moments throughout the entire load range. The following ultimate load factor for railway bridges shall be used:

$$U = m\,D + 2.3\,(L + I)$$

where D is dead load, L is live load, and I is percentage of live load for impact. m is a factor varying uniformly from 2.0 for span of zero length to 1.6 for span of 100 ft length. For spans over 100 ft, m shall equal 1.6.

The design used shall be such that the member will carry this ultimate load.

G. REPETITIVE LOADS*

1. General

The ultimate strength of concrete or steel subjected to repetitive loading may be less than the static strength because of fatigue. Fatigue failure may occur in concrete, prestressing steel, anchorages, splices or bond.

* Reference, Proceedings, Vol. 60, 1959, page 1.

2. Concrete

Fatigue strength of concrete in both tension and compression shall be considered to depend on the magnitude of stress, range of stress variation, and the number of loading cycles. Since high stresses and stress ranges are common, fatigue shall be considered when repetition of loading cycles of greater than design load may occur.

Fatigue failure is unlikely if the allowable stresses shown in Sec. H, Art. 4b are not exceeded. If a large number of overloads is anticipated, a reduction in the safety factor may occur.

3. Prestressing Steel

Fatigue strength of prestressing steel shall be considered to depend upon magnitude and range of stress, and the number of cycles of loading. Minimum stress is the effective prestress. Maximum stress and range of stress shall depend upon magnitude of live loads or overloads that may be repeated. Range of stress under service loads will usually be small unless concrete is cracked. Cracking will be permitted only under temporary overload.

Devices for splicing steel may contain strain concentrations that lower fatigue strength. Consideration shall be given to fatigue whenever splices are used.

4. Anchorages

If steel is fully bonded, no difficulty should be expected in anchorage or end bearing as the result of repetitive loads. If unbonded steel subjected to repeated service loads or overloads transmitted directly to the anchorage is used, fatigue strength of the anchorage shall be given special consideration.

5. Bond

Failure of bond under repetitive loading shall be considered unlikely unless there is a significant number of repetitions of overload.

6. Shear and Diagonal Tension

Web reinforcement shall be provided as specified in Sec. K.

7. Design Conditions

Fatigue should not result in a reduction of strength if the following conditions are observed.

a. Flexural compressive concrete stress shall not exceed 0.4 f_c' under either design load or an overload that may be repeated many times, where f_c' is the compressive strength of concrete at 28 days.
b. Tension shall not be permitted in concrete at the critical cross section under either design load or overloads that may be repeated a number of times.
c. Prestressing steel shall be bonded.
d. Web reinforcement shall be provided as specified in Sec. K.

When these conditions cannot be followed, fatigue strength of all elements comprising the prestressed member shall be considered.

H. ALLOWABLE STEEL AND CONCRETE STRESSES

1. Notation

f_c' = Compressive strength of concrete at 28 days.
f_{ci}' = Compressive strength of concrete at time of initial prestress.

f_{cp} = Permissible compressive concrete stress on bearing area under anchor plate of post-tensioning steel.
f_s' = Ultimate strength of prestressing steel.
f_{sy} = Nominal yield point stress of prestressing steel.
f_t' = Flexural tensile strength of concrete; modulus of rupture.
A_b = Bearing area of anchor plate of post-tensioning steel.
A_c = Maximum area of the portion of the anchorage surface that is geometrically similar to and concentric with the area of the bearing plate of post-tensioning steel.

2. Prestressing Steel

a. *Temporary Stresses*

Stress at the anchorage immediately after seating has been effected shall not exceed 0.68 f_s' for material having the stress-strain properties defined in Sec. S. Overstressing for a short period of time to 0.80 f_s' will be permitted, providing the stress, after seating of anchorage occurs, does not exceed 0.68 f_s'.

b. *Stress at Design Loads*

Effective steel stress after loss of prestress shall not exceed 0.55 f_s' or 0.80 f_{sy}, whichever is smaller.

3. Non-Prestressed Reinforcement

Non-prestressed reinforcement provided to resist tension shall be assumed stressed to 20,000 psi.

4. Concrete

Beams and girders shall be comprised of single elements.

a. *Temporary Stresses*

Concrete stress in psi before losses due to creep and shrinkage shall not exceed the following:

Compression:
- For pretentioned members ..... $0.60 f'_{ci}$
- For post-tensioned members ..... $0.55 f'_{ci}$

Tension:
- For members without non-prestressed reinforcement ..... $3\sqrt{f'_{ci}}$
- For members with non-prestressed reinforcement provided to resist the tensile force in the concrete computed on the basis of an uncracked section ..... $6\sqrt{f'_{ci}}$

b. *Stresses at Design Loads*

After full prestress losses, stresses in psi shall not exceed the following:
- Compression ..... $0.40 f_c'$
- Flexural tension in the precompressed tensile zone ..... Zero

c. *Stress at Cracking Load*

Flexural tensile strength (modulus of rupture) shall preferably be determined by test. When test data are not available, the ultimate flexural tensile stress in psi may be assumed as:

$$f_t' = 7.5\sqrt{f_c'}$$

For lightweight concrete, f_t' shall be determined by tests.

d. *Anchorage Bearing Stresses*

The maximum allowable stress at the post-tensioning anchorage in end blocks adequately reinforced in conformance with Sec. N, Art. 4 shall be assumed as:

$$f_{cp} = 0.6\, f'_{ci} \sqrt[3]{A_c/A_b}$$

The allowable value of f_{cp} should not exceed f'_{ci}.

I. LOSS OF PRESTRESS

1. Notation

T_o = Steel stress at jacking end.
T_x = Steel stress at point X.
e = Base of Naperian logarithms.
K = Friction wobble coefficient per foot of prestressing steel.
L = Length of prestressing steel element from jacking end to point X in feet.
α = Total angular change of prestressing steel element in radians from jack to point X.
μ = Friction curvature coefficient.
n = Ratio E_s/E_c.
u_s = Strain in concrete due to shrinkage.
u_e = Strain in concrete due to elastic shortening.
u_d = Strain in concrete due to creep.
E_s = Modulus of elasticity of prestressing steel.
δ_1 = Ratio of loss in steel stress due to relaxation of prestressing steel.
δ_2 = Ratio of loss in steel stress due to friction during prestressing.
f_{si} = Initial stress in prestressing steel after seating of the anchorage.

2. Sources of Prestress Loss

a. *Friction Loss in Post-Tensioned Steel*

If post-tensioned steel is draped, or irregularities exist in alinement of ducts, steel stress will be less within the member than at the jack because of friction between prestressing steel and duct. Magnitude of this friction shall be estimated for design and verified during stressing operation.

Friction loss shall be estimated from an analysis of force exerted by prestressing steel on duct. One method for determination of friction loss at any point is by the following formula:

$$T_o = T_x\, e\, (KL + \mu\, \alpha)$$

For small values of KL and $\mu\, \alpha$, the following formula may be used:

$$T_o = T_x\, (1 + KL + \mu\, \alpha)$$

The following values of K and μ are typical and shall be used as a guide. They may vary appreciably with duct material and method of construction. Values of K and μ used in design shall be indicated on the plans for guidance in the selection of materials and methods that will produce results approaching the assumed values.

Type of Steel	*Type of Duct or Sheath*	*Usual Range of Observed Values*		*Suggested Design Values*	
		K	μ	K	μ
Wire cables	Bright metal sheathing	0.0005–0.0030	0.15–0.35	0.0020	0.30
	Galv. metal sheathing	----	--	0.0015	0.25
	Greased or asphalt-coated and wrapped	0.0030	0.25–0.35	0.0020	0.30
High-strength bars	Bright metal sheathing	0.0001–0.0005	0.08–0.30	0.0003	0.20
	Galv. metal sheathing	----	----	0.0002	0.15
Galvanized strand	Bright metal sheathing	0.0005–0.0020	0.15–0.30	0.0015	0.25
	Galv. metal sheathing	----	----	0.0010	0.20

Workmanship in placing, supporting, tying and fabricating prestressing elements and ducts influences the magnitude of wobble factor, K. The larger the sheath or duct in relation to the size of the prestressing steel element, the smaller K will be. With normal placing tolerances, wobble effect shall be neglected if the sheath is 1 in greater in diameter than the prestressing steel element.

Effect of overestimating friction loss shall be considered, since excessive prestress may cause undesirable permanent stress conditions. Underestimating friction loss may result in an error in computing cracking load and deflection.

b. *Elastic Shortening of Concrete*

Loss of prestress caused by elastic shortening of the concrete shall be considered. This loss equals $n\ (\Delta f_c)$. For pretensioned concrete Δf_c is the concrete stress at the center of gravity of the prestressing steel for which the losses are being computed. For post-tensioned concrete where the steel elements are not tensioned simultaneously, Δf_c is the average concrete stress along one prestressing element from end to end of the beam caused by subsequent post-tensioning of adjacent elements.

c. *Shrinkage of Concrete*

Shrinkage shall be considered as depending on many variables. Unit shrinkage strain may vary from near 0 to 0.0005. A value of 0.00025 may usually be used for calculation of prestress loss.

d. *Creep of Concrete*

Creep shall be considered as the time-dependent strain of concrete caused by stress. For pretensioned and post-tensioned bonded members, concrete stress shall be taken at the center of gravity of the prestressing steel under effect of prestress and permanent loads (normal conditions of unloaded structure).

In post-tensioned unbonded members, stress shall be considered the average concrete stress along the profile of center of gravity of the prestressing steel under the effect of prestress and permanent loads. Additional strain due to creep shall be assumed to vary from 100 percent of elastic strain for concrete in very humid atmosphere to 300 percent of elastic strain in very dry atmosphere.

e. *Relaxation of Steel Stress*

Loss of stress due to relaxation of prestressing steel shall be provided for in the design. Loss due to relaxation depends primarily on properties of the steel and initial prestress. This loss shall be assumed to be 4 percent of the initial steel stress.

3. Procedure for Estimating Prestress Loss

Method 1 shall be used when individual losses may be predicted with a reasonable accuracy. Method 2 shall apply when specific loss data is not available.

The ultimate strength is not significantly affected by the magnitude of steel stress loss. An error in choosing the loss is reflected in the cracking load and amount of camber.

Method 1:

The total stress loss in prestressing steel

$$\Delta f_s = (u_s + u_e + u_d)\, E_s + \delta_1 f_{st} + \delta_2 f_{st}$$

Methods 2:

Loss in steel stress not including friction loss shall be assumed as follows:

Pretensiong ..... 35,000 psi
Post-tensioning ..... 25,000 psi

For camber calculations, these values may be excessive.

4. Lightweight Concrete

Losses due to concrete shrinkage, elastic shortening, and creep shall be based on results of tests made with the lightweight aggregate to be used.

J. FLEXURE

1. Notation

f_c' = Compressive strength of concrete at 28 days.
f_s' = Ultimate strength of prestressing steel.
f_{su} = Stress in prestressing steel at ultimate load.
f_{se} = Effective steel prestress after losses.
f_y' = Yield-point stress of conventional reinforcing steel.
A_s = Area of main prestressing tensile steel.
A_{sr} = Steel area required to develop the ultimate compressive strength of the web of a flanged section.
A_{sf} = Steel area required to develop the ultimate compressive strength of the overhanging portions of the flange.
d = Distance from extreme compressive fiber to centroid of the prestressing force.
b = Width of flange of a flanged member or width of a rectangular member.
b' = Average width of web of a flanged member.
t = Average thickness of the flange of a flanged member.
$p = A_s/bd$; ratio of prestressing steel.
p' = Ratio of conventional reinforcement.
M_u = Ultimate moment.
k_2 = Ratio of distance between extreme compressive fiber and center of compression to the depth to neutral axis.
$k_1 k_3$ = Ratio of average compressive concrete stress to the cylinder strength, f'_c.

2. Stresses Due to Dead, Live and Impact Loads

Prestressed concrete members shall be assumed to function as uncracked members subjected to combined axial and bending forces, provided stresses do not exceed those given in Sec. H.

In calculations of section properties prior to grouting, areas of the open ducts shall be deducted. The transformed area of bonded reinforcement may be included in pretensioned members and post-tensioned members after grouting.

For calculation of stress due to prestress in T-beams, no definite recommendations are made, but attention shall be given to the possibility that the entire available flange width may be included in calculation of section properties.

3. Ultimate Flexural Strength

a. *General Method*

Rectangular Sections—

For rectangular sections or flanged sections in which the neutral axis lies within the flange, the ultimate flexural strength shall be expressed as:

$$M_u = A_s f_{su} d \left(1 - \frac{k_2}{k_1 k_3} \frac{p f_{su}}{f_c'}\right) \quad \text{Equation A}$$

The results of numerous tests have shown that the factor k_2/k_1k_3 may be taken equal to 0.6 for members and materials considered in these specifications. Determination of the value of f_{su} requires the knowledge of the stress-strain characteristics of the prestressing steel, effective prestress, and crushing strain of the concrete. Assumptions shall be made regarding the relation between steel and concrete strains. These assumptions will be different for bonded and unbonded construction.

The ultimate moment may be computed from Equation A whenever sufficient information is available for the determination of f_{su}.

Flanged Sections—

If a flange thickness is less than 1.4 dpf_{su}/f_c', the neutral axis will usually fall outside the flange and the following approximate expression for ultimate moment shall be used, unless the value of b' is smaller than 0.15 b. Then Equation A shall be used.

$$M_u = A_{sr} f_{su} d \left(1 - 0.6 \frac{A_{sr} f_{su}}{b' d f_c'}\right) + 0.85 f_c' (b - b') t (d - 0.5t) \quad \text{Equation B}$$

where $A_{sr} = A_s - A_{sf} =$ the steel area required to develop the ultimate compressive strength of the web of a flanged section.

$A_{sf} = 0.85 f_c' (b - b') t / f_{su} =$ the steel area required to develop the ultimate compressive strength of the overhanging portions of the flange.

The following approximate expressions for f_{su} may be used in the above equations provided the following conditions are satisfied:

The stress-strain properties of the prestressing steel are reasonably similar to those described in Sec. S.

The effective prestress after losses is not less than 0.5 f_s'.

For bonded members $f_{su} = f_s' \left(1 - 0.5 \frac{p f_s'}{f_c'}\right)$

For unbonded members $f_{su} = f_{se} + 15{,}000$, unless the proper value of f_{su} is known from tests of members closely approximating the proposed construction.

Ultimate flexural strength in unbonded members generally occurs at lower values of steel stress than in bonded members. Wide variations between stress levels reflect the fact that several factors influence the stress developed by unbonded steel at ultimate moment. These factors include: magnitude of effective prestress, profile of the prestressing steel, shape of the bending moment diagram, length/depth ratio of the member, magnitude of the friction coefficient between the prestressing steel and the duct and the amount of bonded non-prestressed supplementary steel.

b. *Maximum Steel Percentage*

To avoid approaching the condition of over-reinforced beams for which the ultimate flexural strength becomes dependent on the concrete strength, the ratio of prestressing

steel preferably should be such that pf_{su}/f_c' for rectangular sections and $A_{sr}f_{su}/b'df_c'$ for flanged sections are not more than 0.30.

If the steel ratio in excess of this amount is used, the ultimate flexural moment shall be taken as not greater than the following values:

Rectangular sections—

$$M_u = 0.25\ f_c'\ bd^2$$

Flanged sections—

If the flange thickness is less than 1.4 dpf_{su}/f_c', the neutral axis will usually fall outside the flange and the following formula shall be used:

$$M_u = 0.25\ b'd^2 f_c' + 0.85\ f_c'\ (b - b')t(d - 0.5t)$$

c. *Non-Prestressed Reinforcement in Conjunction with Prestressing Steel*

Non-prestressed conventional reinforcing shall be considered to contribute to the tensile force in the beam at the ultimate moment an amount equal to its area times its yield point providing that:

$$\frac{pf_{su}}{f_c'} + \frac{p'f_y'}{f_c'} \text{ does not exceed } 0.3.$$

If untensioned prestressing steel or other high-tensile-strength reinforcement is used in conjunction with prestressed reinforcement, the ultimate moment shall be calculated by means of Equation A or Equation B.

K. SHEAR

1. Notation

f_c' = Compressive strength of concrete at 28 days.
f_s' = Ultimate strength of prestressing steel.
f_y' = Yield-point stress of conventional reinforcing steel.
f_{se} = Effective steel prestress after losses.
d = Distance from extreme compressive fiber to centroid of the prestressing force.
b = Width of flange of a flanged member or width of a rectangular member.
b' = Average width of web of a flanged member.
j = Ratio of distance between centroid of compression and centroid of tension to the depth d.
s = Longitudinal spacing of web reinforcement.
p = A_s/bd; ratio of prestressing steel.
A_v = Area of web reinforcement at spacing s, placed perpendicular to the axis of the member.
V_u = Shear due to specified ultimate load and effect of prestressing.
V_c = $0.06\ f_c'\ b'\ jd$ but not more than $180\ b'jd$.

2. General

a. *Ultimate Strength*

It is essential that shear failure shall not occur before the ultimate flexural strength required in Sec. J is developed.

b. *Inclined Cracking*

Formation of inclined cracks precedes failure in shear. They are caused by inclined principal tensile stresses that are the resultant of shearing stresses and normal bending stresses. Compressive prestress reduces the principal tensile stress, thereby increasing the load necessary to cause inclined cracks. The use of thin webs will increase inclined stresses.

c. *Conditions for Shear Failure*

The resistance to formation of inclined cracks is greater with large prestress and increasing web thickness. The significance of inclined cracks is less with low ultimate flexural strength caused by low ratio of reinforcement. Their significance is also less with low shear/moment ratios. If the web is adequately reinforced, ultimate flexural strength can be developed.

3. Design of Web Reinforcement

The amount of web reinforcement necessary to develop required ultimate flexural capacity shall be considered a function of the difference between inclined cracking load and ultimate load in flexure. This difference varies rather widely as a function of prestress force, web thickness, amount of tensile reinforcement and shear/moment ratio, but is usually smaller for prestressed concrete than for conventional reinforced concrete. Current design procedures for web reinforcement in reinforced concrete are conservative for prestressed concrete.

The area of web reinforcement for prestressed members of usual dimensions and properties shall be:

$$A_v = \tfrac{1}{2}\frac{(V_u - V_c)s}{f_y' jd}$$

The factor of ½ shall be increased as the member approaches the condition of conventionally reinforced concrete, since the formula does not involve the prestress force and may not be conservative for very low prestress or where only a portion of the reinforcement is stressed.

4. Minimum Quantity of Web Reinforcement

Because of the nature and limited knowledge of shear failures, it is required that some web reinforcement be provided.

Where the web reinforcement is designed in accordance with Sec. K, Art. 3, the minimum amount of web reinforcement shall be $A_v = 0.0025\ b's$.

This web reinforcement may be reduced in members with unusually thick webs, if tests show that the member can develop its required flexural capacity.

5. Spacing of Web Reinforcement

The spacing of web reinforcement shall not exceed three-quarters the depth of the member. In members with relatively thin webs, spacing shall not exceed the clear height of the web.

6. Critical Sections for Shear

Because formation of inclined cracks reduces flexural capacity, the critical sections for shear will usually not be near the ends of the span where the shear is maximum but at some point away from the ends in a region of high moment.

For the design of web reinforcement in members carrying moving loads, the shear shall be investigated within the middle half of the span length. Web reinforcement required at the quarter points shall then be used throughout the outer quarters of the span.

For members carrying a uniformly distributed load, the maximum web reinforcement shall be taken as that required at a distance from the support equal to the depth of member. This amount of web reinforcement shall be provided from that point to the end of the member. In the middle third of the span length, the amount of web reinforcement provided shall not be less than that required at the third points of the span.

L. BOND AND ANCHORAGE

1. Prestress Transfer Bond

Bond between the pretensioned steel and concrete is necessary to establish a prestress in the concrete. The transfer of force from steel to concrete takes place in a finite length in the end region of a member, and the function of the resulting bond, which shall be termed "Prestress Transfer Bond", is anchorage of prestressing steel. Prestressing force varies from near zero at the end to a maximum value some distance from the end. Transfer length shall be considered for short members or those in which the loading conditions may cause cracking in or near the region of prestress transfer.

2. Flexural Bond

Flexural bond shall be considered the bond stress developed as a result of flexure. Bond stress at design loads in uncracked members shall not be considered critical, since the increase in steel stress resulting from flexure is usually not significant.

3. Bond Stress at Ultimate Load

Bond failure should not occur prior to the development of the required ultimate flexural capacity.

For span lengths usually associated with prestressed concrete, bond failure shall not be considered a significant design factor. Bond adequacy in extremely short members (spans of 10 ft or less) shall be investigated by test.

Concrete strength, perimeter shape, area and surface condition of prestressing steel, stress in the steel at ultimate strength, length of transfer zone, and the superimposed load pattern shall be considered as the factors affecting bond.

M. COMPOSITE CONSTRUCTION

1. Definition

Prestressed concrete structures of composite construction are comprised of prestressed concrete elements and plain or conventionally reinforced concrete elements interconnected in such a manner that the two components function as an integral unit. The prestressed elements may be pretensioned or post-tensioned and may be precast or cast in place. The plain or reinforced concrete elements are usually cast in place.

2. Interaction

a. *Shear Connection*

To insure integral action of a composite structure at all loads, a connection shall be provided between the component elements of the structure capable of performing two functions:

(1) Transfer shear without slip along the contact surfaces.

(2) Prevent separation of the elements in a direction perpendicular to the contact surfaces.

b. *Transfer of Shear*

The entire shear shall be transferred by bond, shear keys, or shear connectors.

c. *Anchorage Against Separation*

Mechanical anchorage in the form of vertical ties shall be provided to prevent separation of the component elements in the direction perpendicular to the contact surfaces. Web reinforcement or steel dowels adequately embedded on each side of the contact surface shall be assumed satisfactory mechanical anchorage.

3. Design of Shear Connection

a. *Loading Stage*

The shear connection shall be designed for ultimate load.

b. *Magnitude and Transfer of Ultimate Shear*

The shear at any point along the contact surface shall be computed by the method
$v = (V_u Q)/I$
where V_u = shear due to specified ultimate load and effect of prestressing.

Q = statistical moment of cross section area, below or above the level being investigated for shear, about the centroid.

I = moment of inertia about the centroid of the uncracked cross section.

If the bond capacity is less than the computed shear, full-width shear keys or shear connectors shall be provided throughout the length of the member. Keys or connectors shall be proportioned according to concrete strength of each component of the composite member.

c. *Vertical Ties*

All web reinforcement shall be extended into the cast-in-place concrete.

Spacing of vertical ties shall not exceed 4 times the minimum thickness of the composite elements, or 24 in, whichever is less. The total area of vertical ties shall not be less than that provided by 2 #3 bars spaced at 12 in.

d. *Capacity of Bond*

The following values shall be used for ultimate bond resistance of the contact surfaces.

When the minimum steel tie requirements of Sec. M, Art. 3c are followed: 75 psi.

When the minimum steel tie requirements of Sec. M, Art. 3c are followed and the contact surface on the precast element is artificially roughened: 150 psi.

When additional steel ties in excess of the requirements of Sec. M, Art. 3c are used and the contact surface of the precast element is artificially roughened: 225 psi.

4. Design of the Composite Structures

a. *Design of Composite Section*

Physical properties of the composite section shall be computed on the assumption of complete interaction between component elements. For structures composed of concretes of different qualities, the area of one of the component elements shall be transformed in accordance with the ratio of the two moduli of elasticity.

b. *Beam and Slab Construction*

If the structure is composed of beams with a cast-in-place slab placed on top of the beams, effective slab width shall be computed in the same manner as for integral T-beams.

c. *Allowable Stress with Different Concrete Strengths*

In structures composed of elements with different concrete strengths, the allowable stresses shall be governed by the strength of the portion under consideration.

d. *Superposition of Stress*

Stresses may be superposed in design calculations that involve elastic stresses. Superposition of stresses shall not be used in computing ultimate strength, since inelastic action of the material is involved.

e. *Stress after Structure Becomes Integral*

The properties of the composite cross section shall be used in computing stresses due to loads applied after the structure becomes integral.

f. *Shrinkage Stresses*

In structures with a cast-in-place slab supported by precast beams, the differential shrinkage tends to cause tensile stress in the slab and the bottom of precast beams.

Stresses due to differential shrinkage are important only insofar as they affect cracking load, and when cracking load is significant, such stresses shall be added to the effect of loads.

g. *Ultimate Strength*

Ultimate strength of a composite section shall be computed in the same manner as the ultimate strength of an integral member of the same shape.

N. END BLOCKS

1. Purpose

An enlarged end section, referred to as an end block, may be required to transmit concentrated prestressing forces in a shaped member from the anchorage area to the basic cross section.

End blocks may be required to provide sufficient area for bearing of anchorages in post-tensioned design. They may also be needed to transmit vertical and lateral forces to supports and to facilitate end detailing.

2. Requirements

In pretensioned members with large, concentrated, eccentric prestressing elements, end blocks shall be used. For lightly pretensioned members, or members of rectangular shape, end blocks may be omitted. However, reinforcement shall always be provided in the anchorage zone.

In post-tensioned, shaped members, end blocks shall be provided.

3. Proportioning

Shallow members, generally, shall have an end-block length equal to the depth and deep beams equal to three-quarters of the depth. Length of an end block shall be considered as the distance from the beginning of the anchorage area to the point where the end block intesects the narrowest width of the member.

4. Reinforcement

Reinforcing is necessary to resist tensile bursting and spalling forces induced by the concentrated loads of the prestressing steel.

Reinforcing grids with both vertical and horizontal steel in the plane of the cross section shall be provided near the ends of the beam to resist spalling forces. Closely spaced reinforcement shall be placed both vertically and horizontally throughout the length of the end block to resist tensile forces.

O. COVER AND SPACING OF PRESTRESSING STEEL

1. Cover

The following minimum clear concrete cover shall be used for prestressing steel, ducts, and non-prestressed steel:

Concrete surfaces not in contact with ground ..... 1½ in
Concrete surfaces in contact with ground ..... 2 in

2. Spacings at Ends

a. *Spacing of Pretensioning Steel*

Minimum horizontal or vertical clear spacing between pretensioning steel elements at ends of members shall be 3 times the diameter of the steel or 1⅓ times the maximum size of coarse aggregate, whichever is greater.

b. *Spacing of Post-Tensioning Ducts*

The clear space between conduits at the ends shall be a minimum of 1½ in or 1½ times the maximum size of the coarse aggregate, whichever is greater.

c. *Dimensions of Post-Tensioning Ducts*

When steel is placed inside conduits which are to be filled with cement grout, such conduits shall have a minimum inside diameter ¼ in larger than the diameter of the prestressing steel.

3. Draped Prestressing Steel

When prestressing steel is placed in a curved or deflected position, steel or conduits may be bundled together in the middle third of the span length, provided the minimum spacing specified in Sec. 0, Arts. 2a and 2b is maintained for a minimum distance of 3 ft at each end of the member. Excessive bundling may lead to insufficient bond capacity in pretensioned members, resulting in bond slip.

P. BEARINGS

Flat bearing pads of neoprene or other approved elastometric material, in general, shall be used for spans less than 70 ft in length. For spans 70 ft and over, rockers of approved design are recommended.

Material Specifications

Introduction

The nature and economics of prestressed concrete construction require the use of high-strength materials. Ability to sustain high stresses with a minimum of time-dependent change in stress or strain is essential.

These requirements shall be more rigid than those for conventionally reinforced concrete, and highest standards of manufacture and construction shall be observed. Prior to adoption of new materials, sufficient test data shall be obtained to verify properties assumed in design.

Q. CONCRETE

1. Scope

Particular attention shall be given to properties of individual materials used in prestressed concrete and their effect on compressive strength, modulus of elasticity, drying shrinkage, creep, bond strength and uniformity of concrete in place.

When new materials and methods are employed, trial mix investigations shall include tests for drying shrinkage, creep, and modulus of elasticity.

2. Materials

a. *Portland Cement*

Portland cement shall conform to one of the following:

Standard Specifications for Portland Cement (ASTM Designation C 150)

Standard Specifications for Air-Entraining Portland Cement (ASTM Designation C 175)

Standard Specifications for Portland Blast Furnace Slag Cement (ASTM Designation C 205)

Standard Specifications for Portland–Pozzolan Cement (ASTM Designation C 340)

b. *Concrete Aggregates*

Concrete aggregates shall conform to the Standard Specifications for Concrete Aggregates (ASTM Designation C 33) or Standard Specifications for Lightweight Aggregates for Structural Concrete (ASTM Designation C 330).

Mineral composition and soundness of aggregates have a marked influence on compressive strength, modulus of elasticity, drying shrinkage and creep.

Concretes made with some lightweight aggregates exhibit a lower modulus of elasticity, greater creep and drying shrinkage than concretes of the same strength made with aggregates of normal weight.

The range of properties possible in the same concrete mix with different lightweight aggregates may be large. Therefore, when lightweight aggregates are to be used, test data shall be obtained for compressive strength, modulus of elasticity, drying shrinkage, creep, modulus of rupture and bond.

c. *Water*

Water for mixing concrete shall be clean and free of injurious quantities of substances harmful to concrete or to prestressing steel. Sea water shall not be used for making prestressed concrete.

d. *Admixtures*

Certain admixtures may be beneficial to fresh or hardened concrete. However, admixtures shall not be used until shown by test to have no harmful effect on the steel or concrete.

Calcium chloride or an admixture containing calcium chloride shall not be used where it may come in contact with prestressing steel.

3. Proportioning, Batching and Mixing

Measurement and mixing of materials shall be done in accordance with Secs. J and K of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this chapter.

Available materials shall be proportioned to produce concrete meeting specification requirements with a minimum water content. Slump of fresh concrete shall be as low as feasible. Cement, sand and coarse aggregate shall be separately batched by weight. Water and some liquid admixtures may be batched by volume with accurate measuring equipment. Close control of all materials and operations shall be considered essential.

4. Strength

The strength required at given ages and the water cement ratio shall be specified by the designer. Controlled concrete shall be used, and it shall be tested in accordance with Sec. J, Art. 10, of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this Chapter.

R. GROUT

1. General

When required by job specifications, post-tensioned steel shall be grouted to completely fill the void surrounding the prestressing steel with a portland cement grout to insure high flexural bond strength and provide permanent protection for the steel.

2. Materials

Grout shall be made of either cement and water, or cement, fine sand and water. Cement and water shall be used where the cavity is small. Either cement and water or cement, fine sand and water shall be used where the cavity is relatively large.

a. *Portland Cement*

Portland cement shall be as specified for concrete materials in Sec. B of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this Chapter.

b. *Sand*

Sand shall be a natural quartz sand meeting the Standard Specification for Aggregate for Masonry Mortar (ASTM Designation C 144) except for gradation requirements.

The sand shall pass a No. 30 sieve, about 50 percent shall pass a No. 50 sieve, and about 20 percent shall pass a No. 100 sieve.

c. *Water*

Water shall be as specified for concrete materials in Sec. D of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this Chapter.

d. *Admixtures*

No admixture shall be used until shown by test to have no harmful effect on the steel or the grout.

Calcium chloride or an admixture containing calcium chloride shall not be used in grouting post-tensioned members.

3. Proportioning

Proportions of grouting materials shall be based on results of tests made on fresh and hardened grout prior to beginning work. Grout shall have the consistency of thick cream or heavy paint, and shall neither bleed, segregate nor crack, when permitted to stand until setting takes place. It shall be thick enough so that if left to stand in a glass jar, it will solidify without any separation of the grout and water.

S. PRESTRESSING STEEL

1. General

High-tensile-strength steel is required in prestressed concrete to provide necessary internal concrete stresses after losses have occurred. The following types are in common use:

a. High-tensile-strength single wire, applied in the form of assemblies made up of 2 or more substantially parallel wires. They may be used for either pretensioning or post-tensioning purposes.

b. Small-diameter, high-strength strand, shop fabricated, is usually made up of 6 wires helically placed around a center wire. Small-diameter strand is usually, although not exclusively, used for pretensioning purposes.

c. Large-diameter high-strength strand is usually shop fabricated with factory-

attached end fittings for post-tensioned construction. It has 7, 19, 37 or more individual wires.

d. High-strength alloy-steel bars are produced by a cold stretching process. They are available in diameters ranging from ½ in to 1¼ in. Alloy-steel bars are used principally for post-tensioned construction.

2. High-Tensile-Strength Single Wire

High-tensile-strength steel wire shall conform to the Standard Specification for Uncoated Stress-Relieved Wire for Prestressed Concrete (ASTM Designation A 421).

3. Small-Diameter High-Strength Wire Strand

Small-diameter high-strength strand shall conform to the Standard Specification for Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete (ASTM Designation A 416).

4. Large-Diameter High-Strength Wire Strand

Large strand may be made of 7, 19, 37 or more galvanized or uncoated hard-drawn wires helically wound. Because large-diameter strand cannot be given a final stress-relieving treatment, some of its physical properties will differ from those of wire or small strand. Acceptance tests, when required, shall be based on properties of the strand rather than individual wires.

5. Cold-Stretched High-Strength Alloy-Steel Bars

These bars shall be made from alloy steel designated AISI–5160 or AISI–9260. After hot rolling, the bars are heat treated or cold worked. Each bar is then to be cold stretched to a minimum of 90 percent of the specified ultimate strength.

a. *Ultimate Tensile Strength*

High-strength alloy-steel bars shall be produced with a minimum tensile strength of 145,000 psi for all diameters.

b. *Shape of Stress-Strain Curve*

High-strength bars for prestressing shall have a minimum yield strength at 0.2 percent permanent strain, equal to 90 percent of the specified ultimate strength. Minimum elongation after rupture shall be 4 percent in a length of 20 diameters.

c. *Ductility*

Bars for prestressing shall be capable of a reasonable amount of cold deformation without failure. The bar shall have a reduction of area of not less than 15 percent at rupture.

d. *Creep and Relaxation*

Data concerning typical creep and stress relaxation properties of the material shall be obtained from the manufacturer. Special acceptance tests for individual lots are not required.

6. Corrosion

Prestressing steels shall be protected during storage, transit and construction since they are susceptible to corrosion.

The term "stress corrosion" shall be applied to the embrittlement of steel that occurs under the combined effects of high stress and some corrosive environments. It may take place without apparent surface impairment. Normally, steel cast in concrete or properly grouted will not be subject to such corrosion.

When post-tensioned steel is not grouted, special precautions shall be taken to protect the steel (see Sec. W, Art. 3).

T. ANCHORAGES AND SPLICES

1. General

Anchorages for post-tensioning elements consist of:

a. Threaded ends or wedge anchors for bars.

b. Factory-attached end fittings for large-diameter strand.

c. Button-head, sandwich-plate, and conical wedges for parallel-lay wire systems.

d. Conical wedges for small-diameter strand.

Splices are used primarily for bars and shall consist of threaded couplings. Only one bar splice shall be made in any given section of a member with a clear distance of at least 6 in being maintained between the ends of the coupler shields of any two splices.

2. Ultimate Strength

Anchorages and splices shall be capable of developing the ultimate strength of the attached steel elements without excessive deformation.

3. Anchorage Set

Movement of prestressing steel in anchorage during seating shall be stated by the manufacturer and substantiated by test data.

Construction Specifications

Introduction

This section specifies construction procedure that should result in sound and durable structures.

Prestressed concrete members are composed of high-strength concrete and steel. Design stresses are closely controlled, but behavior in service depends upon the specified concrete being properly placed in forms of the correct dimensions around accurately positioned prestressing steel or ductwork for steel. Construction requires accuracy and care. Deviation from careful workmanship may result in an unsafe structure and shall not be condoned.

U. TRANSPORTING, PLACING AND CURING OF CONCRETE

1. General

Transporting, placing and curing of concrete in general shall be as specified in Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this Chapter.

2. Placing

Low-slump, high-cement-content mixes shall be placed in the shortest possible time after mixing is completed to prevent loss of workability.

Concrete shall be deposited close to its final position. The method of placement shall be such that segregation will not occur.

3. Vibration

Internal or external vibration or both shall be used so as to produce a dense, well compacted concrete.

Vibrators shall not be used to move concrete horizontally in the form. Over-vibration shall be avoided.

When internal vibration is used, vibrator heads shall be smaller than the minimum distance between ducts or prestressing steel. Care shall be exercised to avoid damage to or misalinement of ducts for post-tensioning steel.

Judgment shall be used in specifying slump and approved methods of vibration used to achieve maximum compaction. Vibration shall not be considered a substitute for workability.

4. Construction Joints

In long cast-in-place members the use of construction joints is recommended to reduce cracking near supports caused by settlement or movement of shoring and falsework, and to allow for shrinkage. In general, joints shall be placed near falsework supports.

Construction joints shall preferably be perpendicular to prestressing steel. Joints shall not be made parallel to prestressing steel unless the provisions specified in Sec. M. Composite Construction, are followed.

5. Curing

a. *General*

Curing shall start soon after finishing. Curing shall continue until the required strength for application of the prestress force is reached. Fresh concrete shall be protected from rain or the rapid loss of moisture prior to the curing period. Rapid drying shall be prevented until the final design strength is obtained. Where identical precast members are required, curing conditions shall be uniform to maintain proper quality control.

b. *Steam Curing*

Steam curing shall be done in an enclosure capable of containing the live steam in order to minimize moisture and heat losses. The application of the steam shall be delayed from 2 to 4 hr after final placement of concrete to allow the initial set of the concrete to take place. If retarders are used, the waiting period before application of the steam may be increased to from 4 to 6 hr. The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 40 deg F per hour until a maximum temperature of from 140 to 160 deg F is reached. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam, the ambient air temperature shall not decrease at a rate to exceed 40 deg F per hour until a temperature has been reached about 20 deg F above the temperature of the air to which the concrete will be exposed. The concrete shall not be exposed to temperatures below freezing for 6 days after casting.

6. Protection Against Freezing

During periods of freezing temperatures, ungrouted ducts shall be blown clear of water or protected against freezing.

V. FORMS, SHORING AND FALSEWORK

1. General

Forms shall be constructed as specified in Sec. G of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this Chapter, where applicable.

2. Special Requirements

Forms for pretensioned members shall be constructed to permit movement of the member without damage during release of the prestressing force.

Forms for post-tensioned members shall be constructed to minimize restraint to elastic shortening during prestressing and shrinkage. Deflection of members due to the prestressing force and the deformation of the falsework shall be considered in design. Form supports shall not be removed until sufficient prestressing has been applied to carry dead load, formwork carried by the member and anticipated construction loads.

W. PLACEMENT OF PRESTRESSING STEEL AND APPLICATION OF PRESTRESSING FORCE

1. General

The location of the center of gravity of the prestressing steel, initial and final prestressing force, and the assumed losses due to creep, shrinkage, elastic shortening and friction shown on the plans shall be considered as based on the use of specified materials. Other materials not specified but capable of producing the same results may be used with the approval of the engineer.

Unless tolerances for location of the prestressing steel are shown, a variation of $\pm \frac{1}{8}$ in to $\pm \frac{1}{4}$ in, depending on the size of the member shall be the maximum permitted.

2. Pretensioning Steel

a. *Measurement of Prestressing Force*

Pretensioning force shall be determined by measuring elongation and checking jack pressure on a calibrated gage. When there is a difference of over 5 percent between the steel stress determined from elongation and that shown on the gage, the cause of the discrepancy shall be ascertained and corrected.

If several wires or strands are stretched simultaneously, provision shall be made to induce the same initial stress in each.

b. *Transfer of Prestressing Force*

The force in the prestressing steel shall be transferred to the concrete smoothly and gradually. If the force in the wires or strands is transferred individually, a sequence of release shall be established by the engineer to avoid subjecting the member to unanticipated stress. Any variation in this sequence shall be submitted to the engineer for approval.

c. *Protection*

Steel shall be kept clean and dry. Foreign matter, grease, oil, paint and loose rust shall be removed prior to casting concrete. The surface of the steel shall not be pitted or marred.

Ends of pretensioning steel exposed to weather or corrosive atmosphere shall be protected by a coating of asphaltic material. They shall preferably be recessed in the member, coated with asphaltic material and covered with mortar.

3. Post-Tensioning Steel

a. *Protection*

The steel shall be kept clean and dry. For bonded construction, foreign matter, grease, oil, paint and loose rust shall be removed prior to placing steel in ducts. The surface of the steel shall not be pitted or marred.

For general use in unbonded construction, galvanizing shall be considered to protect the steel from corrosion when coated with grease or asphalt-impregnated material and enclosed in a sheath. Uncoated galvanized steel shall be used only when it is accessible for inspection, and the points of bearing are equipped with special shoes to prevent damage to the galvanizing.

If wrappings and coatings are used on non-galvanized steel, the coating shall protect the steel from corrosion during shipment, storage, construction and after the steel is in place, and it shall permit the movement of steel during prestressing with minimum friction. The method of protection shall be specified or approved by the engineer.

Anchorage and end fittings shall be given a protective treatment consistent with that given the prestressing steel and shall preferably be recessed in the member and covered with mortar.

b. *Placement of Steel and Enclosures*

Ducts or enclosures for prestressing steel shall be positioned and secured to maintain the prestressing steel within the allowable placement tolerances.

Ducts or enclosures shall be free from grease, paint or other foreign matter. Ducts shall be protected against the entrance of foreign matter prior to grouting.

Anchorage hardware to be cast in the number shall be firmly fastened to the forms in the proper location.

c. *Measurement of the Prestressing Force*

Values of total elongation, corrected for assumed friction loss and anchorage set, and corresponding jack pressures at various increments of prestress shall be supplied by the engineer. When a difference of over 5 percent exists between steel stress determined from the corrected elongation and from the corresponding gage reading, stressing operation shall cease. If the cause of the discrepancy is neither faulty measurement nor equipment, the engineer shall immediately be consulted.

d. *Factors Influencing Friction*

As prestressing force is applied, friction between prestressing steel and curved enclosure reduces steel stress at points away from jack. The amount of friction loss shall be considered a function of the degree of curvature, the type and length of prestressing steel, the duct material, the presence of friction reducing agents, the accuracy of placing the duct and the degree of disturbance during concrete placement.

It shall be the responsibility of the contractor to use materials specified and insure that the quality of workmanship results in accurate duct positioning, with minimum displacement during construction.

e. *Prestressing in Stages*

When the prestressing force is to be applied in more than one stage, excessive concrete stresses shall be avoided during intermediate stages. The engineer shall designate the location and magnitude of the forces to be used for each stage and the maximum allowable external loads that may be placed on the member.

f. *Anchorage Set*

For friction-type anchorages the manufacturer or supplier shall state the amount of slip normally expected in seating the anchorage device.

g. *Effect of temperature*

Changes in temperature shall be considered to have little effect on prestressing reinforcement unless there is a significant temperature differential between concrete and steel.

X. GROUTING

1. General

When grouting is specified for post-tensioned members, it shall completely fill all enclosure voids.

2. Mixing

Grout shall be mixed in a mechanical mixer. Immediately after mixing, the grout shall be passed through a strainer into pumping equipment which provides for recirculation. Grout shall be pumped into the duct as soon as possible after mixing and may be pumped as long as it retains the proper consistency, this consistency to be as specified in Sec. R, Art. 3. The pump shall be capable of developing 100 psi.

3. Arrangements of Grout Pipes

Ducts shall be provided with entrance and discharge ports, each of which can be closed. Extension pipes may be used when necessary.

In long members, grout shall be introduced at one end until it discharges from an intermediate point and the point of application moved successively forward. Grout may be introduced at an intermediate point if discharge ports are provided at the duct ends. The sequence shall be planned to insure complete filling. Air outlets will be permitted at high points of the duct profile.

4. Test for Passage of Grout

Free passage of grout from the entrance to discharge port shall be assured. Tests shall be made by pumping water, air or other fluids through the duct. If any fluid is used, it shall be blown out with air before grouting begins.

5. Application of Grout

Grout shall be applied continuously until it flows steadily from the discharge port, indicating the removal of trapped air and water. The discharge port shall then be closed and grouting pressure maintained for the length of time necessary to insure complete filling of the void. The entrance shall then be closed and the pumping nozzle removed.

6. Protection Again Freezing

Adequate precautions shall be taken to prevent freezing of fresh grout. Grouting shall not be performed if the air temperature is anticipated to go below 45 deg F within 48 hr after grouting, unless some approved method of artificial heating is provided.

7. Protection of Fresh Grout

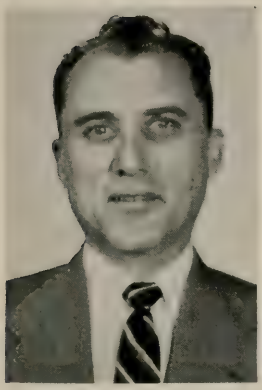
After grouting, the member shall remain undisturbed for a minimum of 3 days.

Y. HANDLING AND ERECTION

1. General

Where precast members are specified, methods of handling and the sequence of erection shall be indicated. When these are not indicated on the plans, the contractor shall submit for approval the location of pick-up points, minimum concrete strength for handling, method of transportation and sequence of erection.

Report of Committee 27—Maintenance of Way Work Equipment



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F. E. Yockey
G. L. Zipperian
Committee

* Died May 23, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Chapter 27 of the Manual is being reviewed, looking to reapproving the material or recommending revisions in 1961 and 1962.

   (a) Revision of Handbook of Instructions for Care and Operation of Maintenance of Way Equipment.

   Progress report, including recommended additions ..... page 492

3. Basis for replacement of work equipment, collaborating with Committee 11.

   Brief progress statement, presented as information ..... page 500

4. Improvements to be made to existing work equipment.

   Progress report, presented as information ..... page 500

5. Equipment and supply cars for mechanized gangs.

   Final report, presented as information ..... page 503

6. Spot tampers.

   Final report, presented as information ..... page 512

7. Use of hour meters on work equipment.
Final report, presented as information ..... page 513

9. Instructions for the care and safe operation of welding equipment.
Final report, presented as information ..... page 515

11. System vs. division shops for maintaining work equipment.
Final report, presented as information ..... page 538

THE COMMITTEE ON MAINTENANCE OF WAY WORK EQUIPMENT,
F. L. HORN, *Chairman.*

AREA Bulletin 554, December 1959.

MEMOIR

Forrest Henry McKenney

Forrest Henry McKenney, engineer of track, system, of the Burlington Lines at Chicago, passed away on May 23, 1959. He is survived by his wife, Mrs. Blanche Miner McKenney; a married daughter, Mrs. Mary Jane Eaten, and two grandchildren.

Mr. McKenney was born on August 10, 1896, in Malcolm, Nebr., the son of William L and Ellen Copeland McKenney. He attended the University of Nebraska's College of Engineering, graduating in 1920 with a B.S. degree in electrical engineering.

In February 1920, Mr. McKenney joined the Burlington as an engineering department draftsman at Lincoln, Nebr., and subsequently served as a transitman, resident engineer on construction of a new line from Vermont to Frederick, Ill., division engineer, assistant engineer in charge of a rail detector car, and district engineer of maintenance of way. He was named engineer of track for the Burlington system, with headquarters in Chicago, in January 1953, which position he held at the time of his death.

He was chairman of the Board of Trustees of the First Methodist Church in Western Springs, Ill., and a member of the Roadmasters' and Maintenance of Way Association of America, and of the Maintenance of Way Club of Chicago.

Mr. McKenney became a member of the AREA on August 15, 1939, and of Committee 27 in 1940. He was active in committee work and served as chairman of various subcommittees.

His dedication to duty, sincerity of purpose and friendly manner will be missed by his co-workers and many other friends and acquaintances.

S. E. TRACY
R. E. BERGGREN
T. H. TAYLOR
Committee on Memoir

Report on Assignment 1 (a)

Revision of Handbook of Instructions For Care and Operation of Maintenance of Way Equipment

S. E. Tracy (chairman, subcommittee), R. E. Berggren, L. E. Conner, J. W. Cummings, C. F. Lewis, H. F. Longhelt, J. W. Risk, F. E. Short, M. M. Stansbury, G. L. Zipperian.

In 1959 your committee submitted reports on three units of equipment with the recommendation that they be included in the next revision of the Handbook.

Investigation develops that the five additional machines covered by this year's report have sufficient general distribution and use to justify writing instructions covering their care and operation.

It is the recommendation of the committee that this material also be included in the next revision of the Handbook.

COMBINATION TAMPER-JACK—TYPE 3

(1960)

DESCRIPTION: This is an on-track machine mounted on four flanged wheels and consists of a power plant to drive a rotary-type air compressor and an hydraulic pump. The air compressor provides the power for the control and operation of four tamping tools suitably mounted in a frame at the front end of the machine to permit vertical movement and adjustment. One tool is positioned on each side of the tie between the rails. The machine is propelled by an hydraulic motor through a two-speed transmission. Two independently controlled and operated hydraulic rams mounted in a frame in a vertical position at the front end of the machine are lowered into the ballast outside the rail between the ties to raise and level the track. The machine is equipped with an hydraulic lift and turntable.

USE: Raising track in out-of-face surfacing operations.

APPROXIMATE WEIGHT:		9000 lb
SPEEDS:	Engine, max	2100 rpm
	Travel, max	20 mph
AIR PRESSURE:	Reservoir	105–115 psi
	Tampers	80– 85 psi
	Raise	Reservoir pressure
HYDRAULIC PRESSURE:	Pump	2100 psi
	Working pressure	1300 psi max

CARE AND OPERATION:

General

The employee assigned to operate this machine shall be governed by the applicable rules covering Tamper-Jacks, Types 1 and 2, in addition to the following:

Starting and Stopping Engine

3.17.55 Before starting the engine:

a Drain water from air reservoir.

b Open shut-off cock on air reservoir.

3.17.56 When engine starts:

a Close shut-off cock on air reservoir.

b Set hand throttle to idle position and operate engine at that speed until engine has warmed up to operating temperature.

3.17.57 When stopping the engine:

a Set hand throttle for maximum engine speed.

b open shut-off cock on air reservoir.

c Turn off ignition.

Traveling

3.17.58 When preparing to travel to and from work:

a Set air operating valve to "travel" position and control valve on air compressor to "unload" position.

b Make sure that all safety pins and locking devices for tamping heads, tampers, lifting rams, rail clamps, leveling devices and center lift are secured in proper position.

Preparing for Work

3.17.59 To prepare machine for raising and leveling track:

a Remove all stop pins and locking devices.

b Set air operating valve to "tamping" position and control valve on air compressor to "load" position.

c Place transmission shift lever in low gear.

d Spot machine over tie and lower tampers in crib.

e Adjust tamping bars as required to clear base of tie approximately 1 in.

f Spot machine on level track and adjust machine level as required.

g Adjust scale on machine moving to zero at pointer.

h Adjust rail clamps to clear bottom of ball of rail approximately ¼ in.

Towing

3.17.60 The transmission shift lever must be placed in neutral position when necessary to tow this machine.

Center Lift

3.17.61 The center lift and turntable must be used only on level track.

Drive Chains

3.17.62 Keep drive chains tight at all times.

While Working

3.17.63 When making a lift, spot machine so lifting rams will be placed in ballast between the ties.

SPIKE DRIVER—AIR

(1960)

DESCRIPTION: This is a self-propelled four-wheel track-mounted unit consisting of a power plant to drive a rotary-type air compressor which provides the power to propel the machine, stop it, actuate the tie nippers and drive the spikes. It is equipped with four hydraulically positioned and independently controlled spiking hammers suitably mounted on a frame at the front end of the unit to permit

vertical and lateral movement and adjustments as may be required for the various weights of rail and tie plate punchings. An hydraulic-power pack unit provides the power for an integral lift and turntable.

USE: To drive spikes in connection with tie renewals and rail laying operations.

APPROXIMATE WEIGHT:		6900 lb
OPERATING SPEEDS:	Engine, idle	800 rpm
	max	2100 rpm
	Travel, max	20 mph
AIR PRESSURES:	Reservoir	105–115 psi
	Lift cylinders:	
	While driving	35– 40 psi
	Raising	Reservoir pressure
HYDRAULIC PRESSURE:	Max	1000 psi

CARE AND OPERATION:

Starting and Stopping Engine

3.23.25 Before starting the engine:

a Drain water from air motor and air reservoir.

b Open shut-off cock on the air reservoir.

3.23.26 When engine starts:

a Close shut-off cock on air reservoir.

b Set hand throttle to idle position and operate engine at that speed until engine has warmed to operating temperature.

3.23.27 When stopping engine:

a Set hand throttle for maximum engine speed.

b Open shut-off cock on air reservoir.

c Turn off ignition.

Traveling

3.23.28 When preparing to travel to and from work:

a See that air flow control valve is in proper position.

b Raise guide wheels and lock in position.

c See that safety pins and locking devices are in position to prevent movement of hammer carriages and tie nippers.

While Traveling

3.23.29 Travel control valve should not be placed in position to change direction of travel while machine is moving except as may be necessary when spotting from tie to tie.

Preparing for Work

3.23.30 To prepare the machine for driving spikes:

a Lower guide wheels and lock them in position.

b Release hammer carriage and nipper locking devices.

c Move machine if necessary so guide wheels and the right

front wheel of machine are in contact with the gage side of rail.

d Adjust spiking hammers as required, placing center of hammer anvil over head of spike.

e In making adjustments see that bolts are adjusted evenly to prevent binding on slides.

f Adjust depth stop rods as necessary to prevent front head of spike hammer from contact with the base of the rail.

g Place front head of spiking hammer so the flat long portion of the oval faces toward the rail.

While Working

3.23.31 While the machine is driving spikes:

a Set hand throttle to obtain maximum engine speed.

b Keep air flow control valve in "work" position.

c Place swinging head control valve in "on" position.

d Raise guide wheels when necessary to move over switch points and frogs.

Towing

3.23.32 Place transmission and travel control valve in neutral position while the machine is being towed.

Integral Lift

3.23.33 The integral lift and turntable should be used only on level track.

Drive Chain

3.23.34 Drive chain must be kept tight.

Line Lubricators

3.23.35 Adjust needle valve located under cap of line lubricator as necessary to have trace of oil at air exhaust of spike hammers.

3.23.36 Alcohol may be added to oil in line lubricator during cold weather to reduce difficulties due to freezing of spike hammers and valve mechanisms.

BALLAST REGULATOR—TYPE 1

(1960)

DESCRIPTION: This machine is designed for on-track operation and consists of a power plant, directional transmission, hydraulic system and the necessary controls mounted on a frame supported by four flanged cast steel wheels, all of which are chain driven. Mounting brackets on both sides of the machine support the ballast boxes, which contain dressing blades and scarifying teeth. By the use of hydraulic power, sheaves and wire rope, the ballast boxes are raised and lowered into position, and an hydraulic ram provides the means of shifting these attachments horizontally. Vertical adjustment of the ballast box is accomplished by mechanical means. Some units are equipped with small air compressors to actuate the brakes and reversing mechanism.

ATTACHMENTS: Rotary brushes, rotary snow plow, front and rear ballast plows.

USE: To equalize ballast, shape the shoulder and light scarifying.

APPROXIMATE WEIGHT: 11,000 lb

OPERATING SPEED: Engine, max 2400 rpm
Travel, max 20 mph
Working, max 3 mph

		Length	*Dia.* *in*	*Type*	
WIRE ROPE—					
HOIST:	Ballast boxes	27 ft	3/8	Fiber center	6 x 37 I.P.S. Regularlay
	Front plow	13 ft	3/8	Fiber center	
	Rear plow	13ft	3/8	Fiber center	

HYDRAULIC PRESSURE: Max 1000 psi

CARE AND OPERATION:

General

3.4.60 The applicable rules covering Types 1 and 2 under "Cars-Ballast Drainage" shall be observed in addition to the following:

Hydraulic System

3.4.61 An approved lightweight (SAE 10) lubricating oil or an approved oil for hydraulic systems, but not hydraulic brake fluid shall be used on this unit.

Adjustments

3.4.62 Before making the vertical mechanical adjustments at the pivot corner of ballast boxes to compensate for the various heights of rail, see that boxes are properly secured and blocked to prevent personal injury.

3.4.63 See that scarifying bars are properly secured to prevent loss and are in such position to prevent damage to the machine when ballast boxes are raised to the top position.

3.4.64 Before making adjustments to the rear or front plow or other attachments, see that they are properly secured and blocked to prevent personal injury.

Ballast Plow

3.4.65 Keep adjustable blades in proper position to prevent damage to ties.

3.4.66 Before using the plow to move material from the shoulder to the center of the track or vice cersa, see that rail sweeps are lowered into proper position.

Directional Gear

3.4.67 Keep directional gear engaged at all times while the machine is in motion.

3.4.68 Do not shift directional gear while machine is in motion.

3.4.69 Do not disengage directional gear while machine is on turntable.

BALLAST REGULATOR—TYPE 2

(1960)

DESCRIPTION: This machine is designed for on-track operation and consists of a power plant, an automotive-type drive with four-speed transmission and a directional gear mounted on a heavy-duty frame and supported by four 24-in cast-steel wheels. It is equipped with reversible-type ballast regulating wings, and a V-type reversible plow may be installed on the front or rear of the machine. An hydraulic system with the necessary controls provides the power to manipulate the regulating wings, attachments and side set-off mechanism.

ATTACHMENTS: Rotary brushes, snow blower and road-crossing scarifier.

USE: To equalize ballast, shape the shoulders and scarify ballast to permit better drainage, and by use of attachments to scarify ballast through road crossings, remove snow from track and from road crossings.

APPROXIMATE WEIGHT: 14,400 lb

OPERATING SPEEDS: Engine, max 2400 rpm
Travel, max 20 mph
Working, 3 to 5 mph

		Length	*Dia.*	*Type*	
WIRE ROPE—			*in*		
HOIST:	Ballast boxes	27 ft	3/8	Fiber center	6 x 37
	Front plow	13 ft	3/8	Fiber center	I.P.S.
	Rear plow	13 ft	3/8	Fiber center	Regularlay

HYDRAULIC PRESSURE: Max 1000 psi

CARE AND OPERATION:

3.4.75 The applicable rules covering Types 1 and 2 under "Cars—Ballast Drainage" and "Ballast Regulators—Type 1" shall be observed in the operation of this unit

YARD CLEANER—TYPE 3

(1960)

DESCRIPTION: This is a self-propelled off-track machine mounted on four heavy-duty pneumatic tires. It is equipped with a power plant, a positive two-wheel drive through an automotive-type transmission with a two-speed rear axle. It is designed to straddle standard gage track, and the adjustable flanged wheels attached to the floating front-end feeder tend to hold it in proper position for loading. Material is picked up at the front end of the unit by a push-type scraper. An auger forces it into position under a paddle-type conveyor which delivers it to an endless belt conveyor upon which it is carried to the top of the machine where it is deposited upon a swivel conveyor belt

for disposition. The conveyors and front-end feeder assemblies are chain driven by a power take-off, and an hydraulic system provides the power to position them.

USE: Cleaning tracks, loading materials from windrow or stock pile, unloading from drop-end gondolas and handling snow.

APPROXIMATE WEIGHT: 16,500 lb

OPERATING SPEEDS: Engine, while loading 1650 rpm
Engine, while traveling 2400 rpm, max
Travel, max 20 mph

DUMPING HEIGHT: 13-ft swivel conveyor 13 ft 5 in
18-ft swivel conveyor 16 ft 5 in

SWIVEL CONVEYOR SWING: 45 deg, right or left.

TIRES: Size, 14.00 x 24, 8 ply
Pressures—Front, min 40 lb, max 50 lb
Rear, min 25 lb, max 35 lb

CARE AND OPERATION:

General

3.41.35 The employee assigned to operate this unit of equipment shall be governed by the applicable rules under "Yard Cleaners" Types 1 and Type 2, in addition to the following:

Operation

3.41.36 In cold weather make sure conveyor belts are not frozen to pulleys and rollers before engaging clutch which controls them.

3.41.37 Low range of two-speed transmission must be used while loading or unloading materials.

Adjustments

3.41.38 See that flanged wheels on front-end scraper are in proper adjustment for height of rail.

Traveling

3.41.39 Release pressure on hydraulic ram and lock swivel conveyor to prevent movement while traveling.

3.41.40 Do not shift transmission to change direction while machine is in motion.

Report on Assignment 3

Basis for Replacement of Work Equipment

Collaborating with Committee 11

N. W. Hutchison (chairman, subcommittee), T. S. Bean, J. H. Brown, R. E. Buss, L. B. Cann, Jr., L. E. Conner, F. L. Etchison, M. E. Kerns, C. F. Lewis, C. F. Montague, H. C. Pottsmith, J. W. Risk, H. A. Thyng, S. E. Tracy.

The objective of this study is to develop some sort of mathematical formula which may be used as a reliable basis for the replacement of work equipment. Considerable research has been done to determine when and why work equipment should be replaced on the major railroads, and on what basis contractors make decisions to replace their equipment.

It is obvious to your committee that the principal factor underlying the decision to replace or not to replace a unit of railroad work equipment must, of necessity, be the current business conditions in the railroad industry, although the matters of age, condition, obsolescence, operating costs, and maintenance costs are given consideration.

This brief progress report is offered as information. Your committee will continue its study in an attempt to arrive at conclusions that will be of benefit to the Association.

Report on Assignment 4

Improvements to Be Made to Existing Work Equipment

G. L. Zipperian (chairman, subcommittee), L. B. Cann, Jr., S. E. Haines, Jr., W. T. Hammond, R. A. Hostetter, W. E. Kropp, Jack Largent, Paul Martin, F. H. McKenney, P. G. Petri, H. C. Pottsmith, F. A. Schneider, T. H. Taylor.

This is a progress report, submitted as information, and is a continuation of the previous progress reports submitted by this committee and found in Vol. 53, 1952, page 396; Vol. 54, 1953, page 666; Vol. 55, 1954, page 502; Vol. 56, 1955, page 525; Vol. 57, 1956, page 488; Vol. 58, 1957, page 585 and Vol. 59, 1958, page 629. It covers changes in work equipment that this committee has found to be practical and desirable.

Track Broom

This is a four-wheel, rail-mounted, self-propelled machine for sweeping excess ballast from the tops of the ties between and outside the rails and distributing it on the shoulder.

Suggested improvements to this machine:

1. The bonnet covering the rotating brush should be made of heavier material and reinforced to prevent it from becoming distorted by the ballast striking against it.

2. An adjustable 10-in plate on a 45-deg angle should be provided for leveling the ridge of ballast that is left at the heads of the ties after sweeping.

3. Provide an adequate air cleaner of proper design and capacity for the main engine to extend service life.

Ballast Regulator

This is a self-propelled, track-mounted, four-wheel-drive machine for equalizing ballast and shaping shoulders.

Suggested improvements to this machine:

1. The winch for raising the center plow should be mounted on a substantial frame instead of on the hood and hood support brackets.

2. The case of the reversing transmission may break because the short drive shaft with two universal joints connecting to the engine transmission does not allow for end play which may result under hard pulls.

3. The regulator with mounted track-broom attachment requires 25 ft of space to give track clearance when setting off. Should be equipped with jacking cylinders and set-off wheels not requiring it to be turned at right angles to the track.

4. Provide adequate air cleaners of proper design and capacity for the main engine and the auxiliary engine used to drive the broom attachment.

Yard Cleaner

This is a self-propelled machine mounted on heavy-duty pneumatic tires and is used for cleaning tracks and loading windrowed materials. It can also be adapted to off-track ballast-cleaning operations.

Suggested improvements to this machine:

1. Provide an optional diesel or gasoline engine with greater horsepower and a torque-converter drive.

2. The speed of the conveyor belt should be adjustable to the types of digging and materials that the machine is working in.

Gager Track

This is an on-track machine used to position tie plates and drill holes in ties for anchor plugs or spikes in out-of-face rail laying. A separate crawler pushing attachment ridden by an operator is available instead of pushing the machine manually.

Suggested improvements to this machine:

1. The present crawler machine which pushes the gaging machine should be redesigned so that it will be a self-propelled pre-gager pulling the gaging machine, eliminating the present manually propelled pre-gager. The gaging operation would then be a two-machine operation instead of three.

2. As an alternate, the present self-propelled pushing device should be controlled by the gager operator instead of having another operator.

3. The pusher should be powered by a simple hydraulic drive instead of the ratchet and pawl device now used, which requires frequent repair.

Tie Bed Scarifier

This is a four-wheel, track-mounted, self-propelled machine used to dig the tie beds to the proper depth for out-of-face tie renewals.

Suggested improvements to this machine:

1. Provide a locking device to hold the machine stationary when scarifying a tie bed in rock or cemented ballast. The machine as it now exists has a tendency to creep back into the original hole, resulting in poor tie spacing.

2. The mechanical drive to the scarifying shaft should be redesigned to eliminate the open chain and sprockets exposed to ballast when inserted into the crib. The universal joints are light and wear out rapidly. The bearings on which the rotating shaft is mounted are not adequately sealed against dirt and grit, making frequent replacement necessary.

3. The scarifying teeth should be made of harder material to avoid the need of frequent replacement.

4. A more substantial turntable and run-off rails should be supplied with this machine.

Combination Tamper-Jack

This is a four-wheel, track-mounted, self-propelled machine used in surfacing operations to raise track hydraulically and tamp sufficient ties to eliminate the need of leveling jacks.

Suggested improvements to this machine:

1. Provide a shut-off valve between the hydraulic oil reservoir and the pump in the suction line.

2. The tie nipper should be redesigned as it now requires a man to dig out ballast from the ends of the ties. If the ballast is not removed, the tamping motors strike it and also results in splitting of ties. Should have more travel so no adjustment is necessary to nip 8- or 9-ft ties.

3. The cross level and pointer indicator device should be adaptable to the existing wire, track-surfacing machine and substantially mounted.

4. The hydraulic controls with relation to the operator's position when he is seated are difficult to reach, resulting in excessive fatigue and loss of production.

5. Should be redesigned for four-wheel drive instead of two to provide better traction for travel.

Spot Tamper

This is a four-wheel, track-mounted, self-propelled machine with a movable head, making it possible to tamp the ties under either rail. It is used in out-of-face spotting.

Suggested improvements to this machine:

1. Increase the capacity of the compressor to a minimum of 160 cfm.

2. Add a line lubricator close to the tamping guns to insure their proper lubrication.

3. The poppet-type air valves stick between seats and give considerable trouble, resulting in drop of air pressure.

Combination Tamper-Jack

This is a four-wheel, track-mounted, self-propelled machine, used in surfacing operations to raise track hydraulically and tamp sufficient ties to eliminate the need of leveling jacks.

Suggested improvements to this machine:

1. Replace the hand lever used to set and release the rail clamps with a hydraulic cylinder synchronized with the travel so the clamps must be clear of the rails before travel can be engaged. The safety chain holding the clamp clear of the rail is unreliable; the clamp has fallen while the machine was moving.

2. Install a pipe safety railing around the operator's platform.

3. Improve the reversing clutches for moving this machine so spotting for the tie to be tamped is not so difficult.

Report on Assignment 5

Equipment and Supply Cars for Mechanized Gangs

A. C. Danks, Jr., (chairman subcommittee), R. M. Baldock, O. C. Benson, I. M. Boone, P. H. Cole, E. H. Fisher, N. W. Hutchison, A. W. Munt, V. W. Oswalt, Sr., F. N. Snyder, T. H. Taylor, L. B. Waterman

This is a final report, presented as information. It is supplemental to reports submitted previously which may be found in the Proceedings, Vol. 51, 1950, pages 261–263, incl., and Vol. 52, 1951, pages 367–372, incl.

After analyzing the reports received from many roads, it is apparent that there is a great need for specially designed equipment and supply cars for mechanized gangs. The right kind of special equipment will minimize the manpower needed for loading equipment, reduce lost time of manpower and equipment in moving from job site to job site, reduce "down" time of equipment, and improve safety and work conditions.

In general, there are three methods for handling equipment and supplies for mechanized gangs:

1. *Use of Off-Track Vehicles*—This method is not covered by this report. Various roads have constructed special trailers, special panel trucks, motor trucks with retractable flanged wheels, and many other similar types of rubber-tired equipment. This type of equipment, when usable, permits flexibility of operation and minimizes interference to revenue traffic.

2. *Use of Standard Rolling Stock*—Though used by many roads, this method is the least desirable. When a move is to be made from one work site to another, available revenue cars are obtained, and the equipment and supplies are loaded and transported to the next work site. This method, of course, causes considerable time delay and requires many costly man-hours. Roads now using this method are taking steps toward acquiring special cars and off-track vehicles.

3. *Use of Specially Equipped Rolling Stock*—This method is used quite extensively, primarily by the larger roads which have many similar sets of identical work equipment and are thus warranted in constructing a fleet of special cars to handle specific units of machinery.

There are included in this report photographs (Figs. 1 to 16, incl.) showing a few of the many special devices which have been developed by individual roads to suit their own specific needs. In all cases, existing rolling stock of the proper kind and load-carrying capacity has been converted to fit the specific needs for which it is to be used. For example:

1. Living cars have been constructed by modifying old coaches, pullman cars, baggage cars or box cars.
2. Water cars have been developed from old tank cars or locomotive tenders. Tool and supply cars generally are constructed by modifying box cars.
3. Equipment-carrying cars are made from flat or gondola cars. Usually, these cars are equipped with light rail ramps to facilitate loading and unloading of work equipment.
4. Combination equipment and supply cars are made from either a box car with one end cut off or from a flat car with an end of a box car set on.

In general, each road has used its own ingenuity to construct the cars needed to serve its own specific purposes from available existing rolling stock.

(Text continued on page 512)

Fig. 1—Small rail crane loaded on flat car by use of rail ramps.

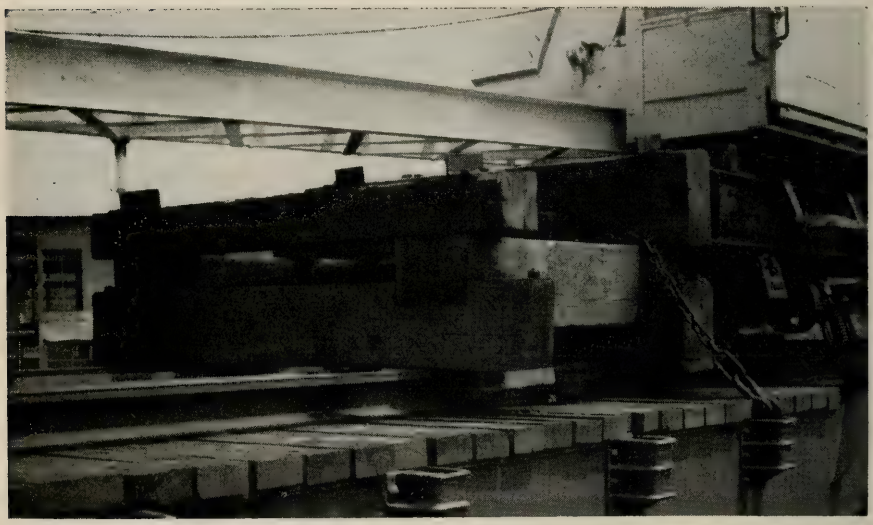

Fig. 2—Portable crib blocking in place under crane boom.

Fig. 3—Crane in position on flat car, tied down ready for movement.

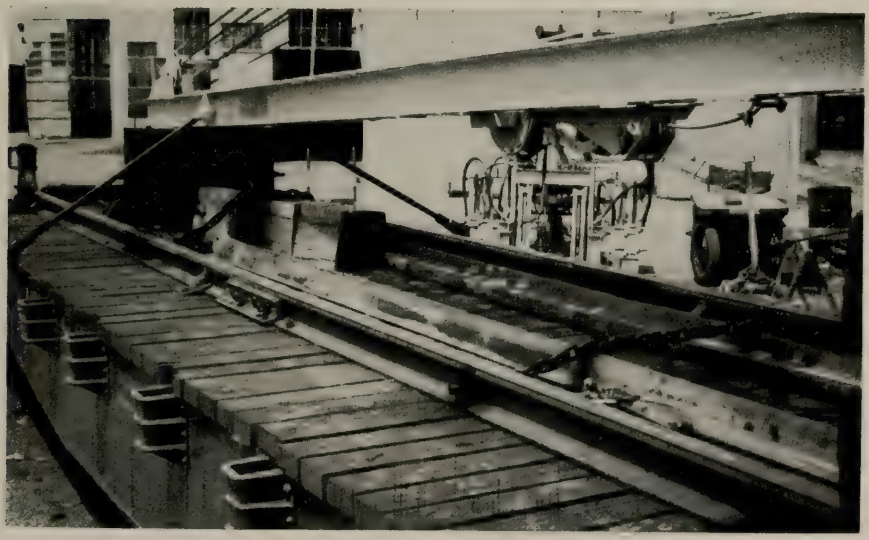

Fig. 4—Crane boom blocked and tied down ready to be moved. Note ramp rails and blocking tied down between the running rails.

Fig. 5—Tamping machine loaded on special flat car by running it up ramp rails.

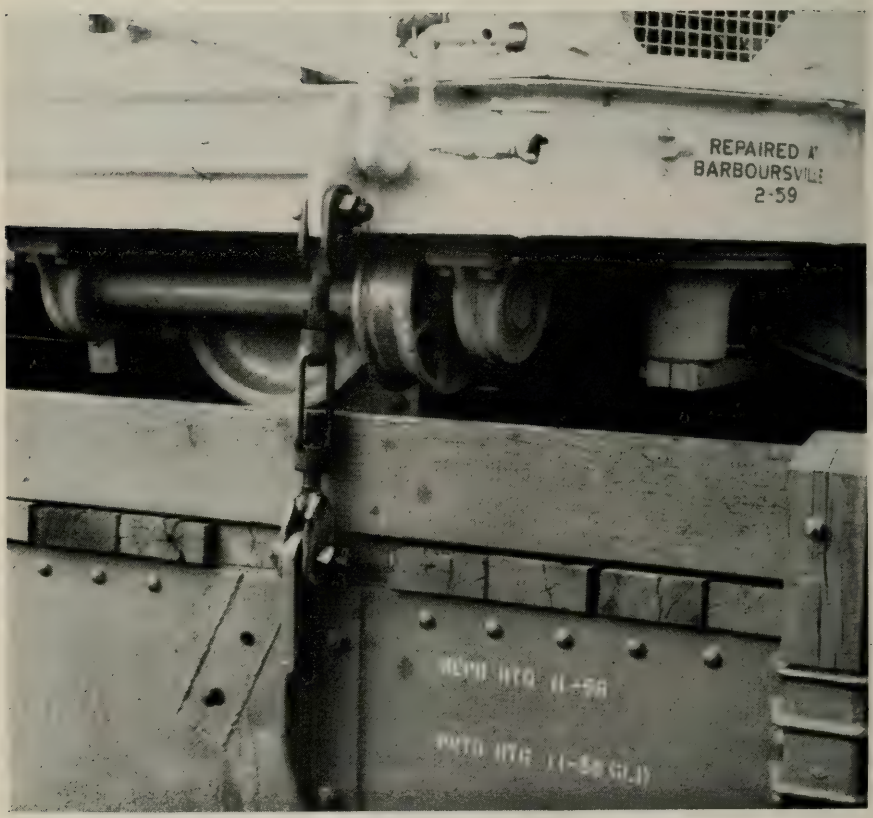

Fig. 6—Special tie-down device to hold tamping machine secure for movement in revenue freight train.

Fig. 7—Tamping machine tied down on special flat car, ready to be moved.

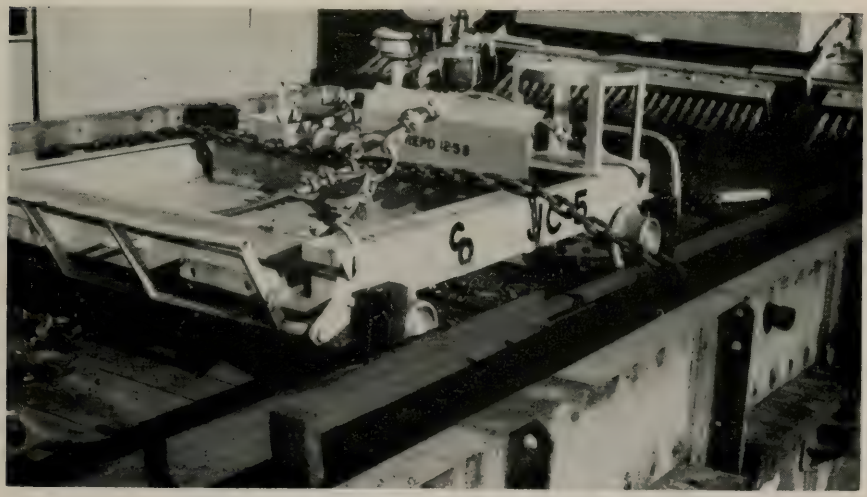

Fig. 8—Jack carrier ready to be moved.

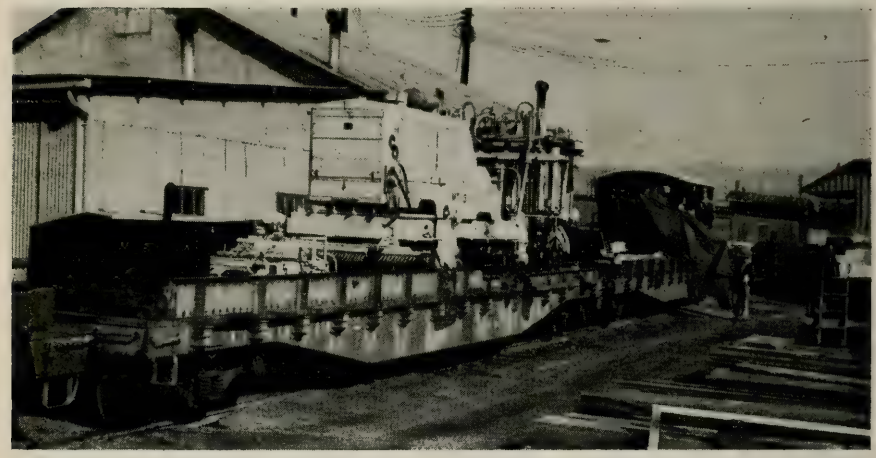

Fig. 9—Tamping machine and jack carrier on special flat car, ready to be moved.

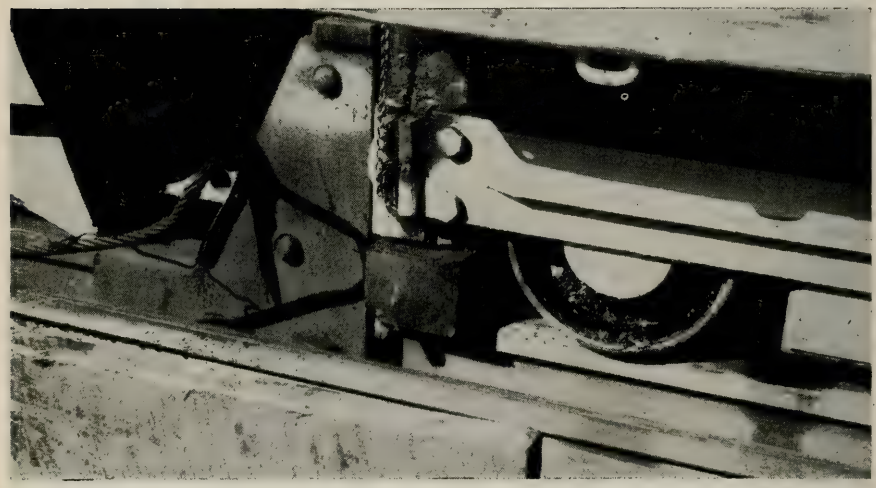

Fig. 10—Wheel blocking device for securing equipment on flat cars.

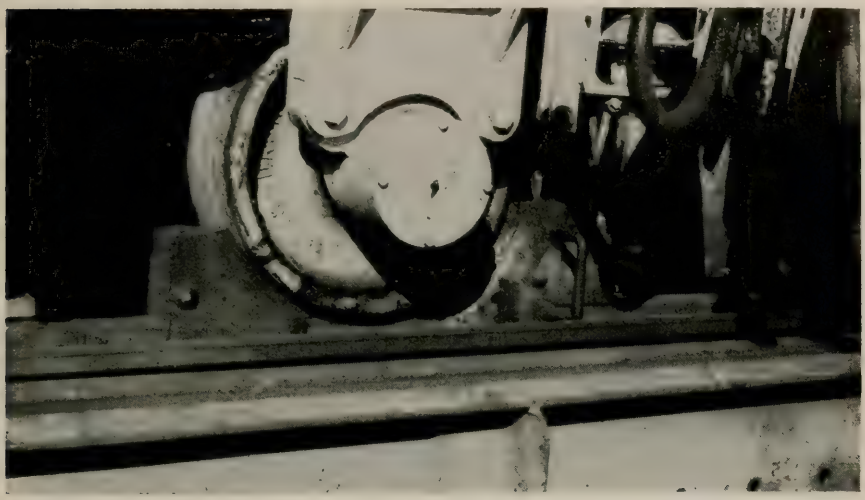

Fig. 11—Another type of wheel blocking device for securing equipment on flat cars.

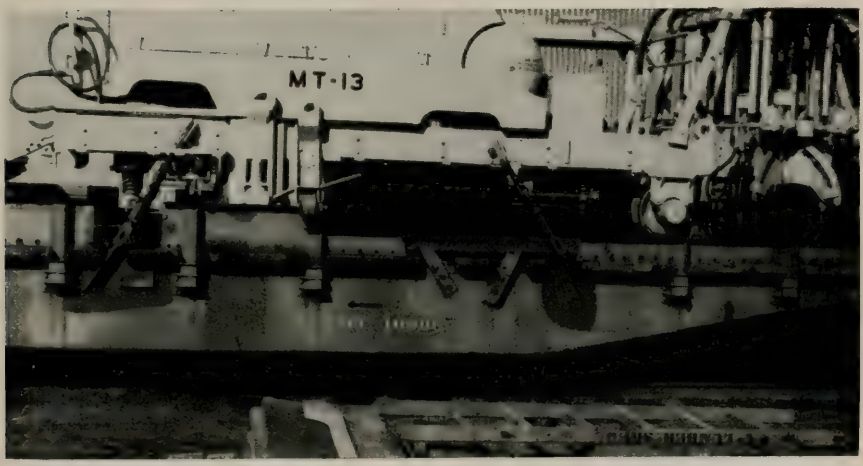

Fig. 12—Turnbuckle tie-down arrangement for securing equipment to special flat cars.

Fig. 13—Special flat car with ramp rails in place for equipment loading.

Fig. 14—Tamping machine on ramp rails.

Fig. 15—Two tamping machines loaded on special flat car, tied down ready to be moved.

Fig. 16—Special tool car for carrying supplies for tamping machines.

Conclusions

In the interest of more expeditious and safer handling of work equipment it is desirable to have specially constructed cars for transporting work equipment and supplies on-track. When practical, it may be more desirable to have rubber-tired vehicles for transporting work equipment and supplies off-track.

Report on Assignment 6

Spot Tampers

J. O. Elliott (chairman, subcommittee), R. E. Berggren, G. R. Collier, Wm. Glavin, H. D. Hahn, R. A. Hostetter, W. E. Kropp, Paul Martin, J. E. Reynolds, G. E. Roberts, N. E. Smith, R. S. Stephens.

This is a final report, submitted as information.

"Spot Tampers" are considered in this report as those types of on-track machines designed primarily for spot work and not for out-of-face production tamping, although some railroads use the production, split-head-type machines because of their adaptability for spot tamping also.

The spot tampers vary considerably in size, and weigh from 1940 to 13,500 lb. One of the smaller tampers consists of a single-cylinder, air-cooled 5.2-hp (at 2500 rpm) gasoline engine powering a direct-driven power pack which includes a hydraulic pump, reservoir and relief valve. The four control valves are of the open-center type and govern the vertical and lateral movement of the tamping heads, tilt of tamping tools and the propelling of the machine. The tamping tools use 8 cu ft per minute, develop 7 ft-lb per blow, and operate at 1420 blows per minute. A detachable compressor furnishes air for the four tamping tools and the rail clamp. This tamper weighs 1940 lb, including compressor and pneumatic-tired wheels, and lift handles provide a wheelbarrow-action set-off feature. This machine is designed to work in most types of ballast sections, and its over-all size (8 ft long, 9 ft 10 in wide, 6 ft 4½ in high) will permit transporting it in most dump or stake-body trucks.

Another small spot tamper is powered by a 4-cycle, 15-hp, air-cooled gasoline engine. This motor drives a low-pressure 500 psi hydraulic system which controls the four tamping heads. The tamping heads develop 14 ft-lb per blow, deliver 1160 blows per minute at 2800 rpm and have a vibrating action to bring the ballast to the tamping head. This machine weighs 2100 lb complete, and is 8 ft long, 6 ft wide and 5 ft high. A combination manual and power hydraulic lift jack is provided for turning the machine and a power winch is provided to help set the machine back on the track. This tamper is designed to work in most ballast sections but performs better in clean, small-size ballast. Pneumatic tires are mounted to provide a wheelbarrow arrangement when setting off track. Added features are that the main head on which the four tools are mounted can be swiveled to allow tamping crooked ties, and its size will permit easy moving on dump or stake-body trucks.

A larger spot tamper weighs 9500 lb, and is 13 ft 1 in long, 7 ft 9 in high and 10 ft 5 in wide while working, but its width is adjustable to only 8 ft while traveling. This tamper comes with a diesel or gasoline engine which drives a 125-cu-ft rotary compressor and a hydraulic pump. The machine propulsion is by hydraulic motor through a 3-speed transmission at speeds from 8.5 to 20 mph. It has four-wheel air and hand brakes. The four air tamping tools are mounted to operate along a cam-plate design which moves the tamping tools in a definite pattern so as to force the tools under the

rails with a down pressure of 400 psi. The tamping tools are mounted on a slide axle, allowing traversing of the tamping head from one rail to the other. Each tamping tool develops 11 ft-lb per blow and operates at 1440 blows per minute, using 14 cu ft of air per minute. The machine has hydraulic track jack and hydraulic lift with turntable. This tamper is well adapted to tamp ballast in about 75 percent of turnouts and works well in most types of ballast sections.

The production and adaptability of the various spot tampers depend primarily on the physical condition of the track or railroad to be given a smooth-up operation. Several spot tampers are small enough to be moved easily by truck from one location to another if conditions necessitate this practice, and one tamper is designed to permit tamping crooked or slewed ties. Another tamper is designed to tamp under both or only one rail at the same time, while several tampers are fitted with pneumatic-tired wheels to provide a wheelbarrow arrangement to set the machine off the track. Several spot tamping machines are still in the planning and testing stages, and many improvements are expected in the near future. Production now varies from 300 to 1000 ft per hr, depending on the type of ballast used.

Report on Assignment 7

Use of Hour Meters on Work Equipment

C. F. Montague (chairman, subcommittee), R. W. Bailey, S. E. Haines, Jr., H. Hornbuckle, S. H. Knight, W. F. Kohl, P. G. Petri, F. A. Schneider, R. J. Smith, R. S. Stephens, T. H. Taylor, C. R. Turner.

Your subcommittee submits the following report as information, with the recommendation that hour meters be placed on all items of work equipment when practicable.

Reasons for Use

The application of an engine hour meter, also known as a running-time recorder, to a machine or item of equipment provides:

1. An accurate account of how much time the equipment is actually being used.
2. A definite time for lubrication, oil change, and other service requirements.
3. An index or guide of service life of the unit.

Cost

The cost of their application to work equipment is nominal, and their use on all except small equipment is recommended.

Types or Classes

Hour meters may be divided into two classes based on their method of operation. In the first of these are the mechanical counters, which record the revolutions of the crankshaft of the engine to which applied. In the second class are the electrically operated timers, which record the time that the engine is running.

According to the method of reading, these meters may be separated into three classes.

1. Those affording a direct-count reading of numerals from the face of the meter. These are made with four or five numerals and can be obtained to read in hours only, hours and tenths of hours, or hours and hundredths of hours.
2. Those with pointers or needles indicating the time on a dial type of face. These are available to record up to 9999 hr.

3. Those recording on paper charts by means of a stylus or pen. Since these do not give a record of over 24 hr, their use is more adaptable to making time studies on machine processes in factories, etc., than for application to roadway machinery or work equipment for the purposes previously outlined. For this reason they are not discussed further in this report.

Size

The engine hour meters are all of small size, requiring a mounting area no greater than 4½ in. in height, width or diameter, and no greater than 3¼ in. in depth.

Application and Operation of Revolution-Counter Type

The mechanical revolution-counter type, although primarily designed and furnished for application as original equipment on several makes of gasoline and diesel engines, can be obtained completely housed in a small rectangular case which can be mounted to a panel or bracket with small bolts or studs. One model has a drive shaft with a single tang that mates with a slot in the driving member from the engine; another model has a drive shaft with a worm gear for connection to the driving member. Both types have a standard ratio of 10,000 revolutions of the drive shaft to record one figure, although other ratios can be provided by the manufacturer. When not installed as original equipment, this type of engine hour meter requires that a design of take-off, or connection from the engine to the meter, be worked out; consequently it is more difficult and costly to apply than an electrically operated meter.

Application and Operation of Electric-Timer Type

The electrically operated types are easy to install in instrument panels, or with brackets for mounting in any convenient location and position They are housed in cylindrical cases, with a round or square bezel or mounting flange, and with wire terminals on the back of the case. They can be obtained to operate on direct current of 6, 12, 24 or 32 v, also on various a-c voltages and cycles. When used on engine so equipped, the current source wire is connected to the battery through the manually operated ignition switch, or if desired, through a switch actuated by the oil pressure of the engine; the ground wire is suitably connected to secure a ground. By using an oil-pressure switch, current will flow to the meter only when the oil pressure rises, and the meter will continue to operate whether the engine idles or is under full load until the engine is stopped. The timing mechanism of this type is an electrically driven clock. One such meter has an electrically wound clock, in which a spring is tensioned approximately every 2 min by the action of an armature pulled magnetically through an arc around a coil. When the armature reaches the fully wound position, the contact points separate. The clock main spring pulls the armature back towards the unwound position through a balance-wheel escapement, and when the unwound position is reached, the contact points again come together, causing the winding operation to repeat. Another electric meter has a synchronous motor which drives a precision drum-type counter whenever power is applied. The first of these electric meters is in common use on many diesel and gasoline engines powering roadway machines or work equipment. The second was developed for use with aircraft engines but could be used also on railroad work equipment.

Service Recorder

Another type of recorder, which cannot be classed as an engine hour meter but which is of value in studying the operation of such vehicles as lift trucks, autotrucks,

etc., is available. Known as a Service Recorder, this is a chart type of meter, completely mechanized in operation, which makes its operating record from the side sway or motion (not vibration) of the machine or vehicle to which it is attached. It records the time that the machine or vehicle is actually in motion, whether or not the engine is running. A sapphire stylus scratches the record on a wax-covered circular chart appropriately marked to show the hour and date, this chart being driven by a spring-wound mechanism. Five models are offered with 4-in-diameter chart for 8-, 12- or 24-hr record; 6-in-diameter chart for 4-, 8-, 12-, 24- or 72-hr record, and a 6-in-diameter chart for a 9-day record, accomplished by a 72-hr clock revolving 3 times. Such a recorder is of value in determining the performance of autotrucks, etc., and could also be adapted to most maintenance of way equipment, should such a record be desired.

Report on Assignment 9

Instructions for the Care and Safe Operation of Welding Equipment

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Previous reports on welding and welding equipment are printed in the Proceedings, Vol. 35, pages 504 to 510, incl.; Vol. 36, pages 278 to 296, incl.; Vol. 38, pages 128 to 131, incl.; Vol. 41, pages 277 to 288, incl.; and Vol. 42, pages 200 to 205, incl.

Acknowledgement is hereby made of information from the following sources:

National Cylinder Gas Company—Safety Rules.
Linde Company—Precautions and Safe Practices.
Air Reduction Sales Company—Safety Precautions and Rules.
American Welding Society—Safety in Welding and Cutting.
Standards of the National Board of Fire Underwriters for the Installation and Operation of Gas Systems for Welding and Cutting.
Association of American Railroads—Electrical Section.
Association of American Railroads—Safety Section.

Much information contained in this report is also contained in the AREA Handbook of Instructions for Care and Operation of Maintenance of Way Equipment.

Previous reports on grinding and grinding equipment are printed in the Proceedings, Vol. 33, pages 168 to 171, incl.; Vol. 35, pages 475 to 482, incl.; Vol. 37, pages 161 to 169, incl., also pages 194 and 195.

Acknowledgement is hereby also made of information from the Handbook mentioned above as well as from the American Standard Safety Code for The Use, Care, and Protection of Abrasive Wheels, Publication ASA B7.1–1956, published by the American Standards Association.

There is in service on the railroads today a large amount of both oxyacetylene and electric welding equipment as well as grinding equipment used in connection with welding. Rules and regulations are essential for the safe, efficient, and economical operation and care of this equipment.

The following instructions cover all welding and grinding equipment used in connection with welding in the maintenance of way departments, both in the field and in shops. They may be used as presented or modified to suit the conditions on any railroad.

INSTRUCTIONS FOR THE CARE AND SAFE OPERATION OF WELDING AND GRINDING EQUIPMENT

PART 1—OXYACETYLENE WELDING OR CUTTING

General

Only those men qualified by the welding inspector, supervisor, or instructor should be assigned to welding or cutting. Helpers or trainees may perform certain welding and cutting under the direct supervision of a qualified welder.

Oxyacetylene Equipment

Personal Safety

1. Equipment should be clean, free from oil and grease and in good working condition at all times. Use no oil. Never let oil or grease come in contact with oxygen, or with any of the equipment through which oxygen passes, to prevent possible explosion. Gloves and clothes must be free from oil and grease.

2. Welder's goggles with prescribed lenses should always be worn when using a torch. They protect the eyes from sparks and flying slag, from the strong light and injurious rays of the flame, and eliminate glare. Proper goggles shall be worn by welders, helpers, trainees, and other employees when chipping, peening, grinding, etc.

3. Suitable gloves, shoes and clothing should be worn.

4. Care should be taken to avoid getting sparks in sleeves, cuffs, and pockets of clothing.

5. Oxygen must never be used to dust off clothing or work.

6. A spark lighter should be used to light a torch. Matches should not be used.

7. When practical, rubbish and flammable material should be cleared from the area (25 ft) before welding or cutting. Flame and sparks should be kept away from cylinders and hose.

8. Never stand in front of the regulator or gage faces when opening station or cylinder valves.

9. All connections must be kept tight and tested for leaks each time a connection is made.

10. Special care should be taken when working on staging suspended by rope to prevent damaging or setting fire to the rope.

11. Tanks and containers that are known to have, or which possibly could have, contained flammable gases or liquids must not be welded or cut on by oxyacetylene torches except when cleaned and welded or cut in accordance with "Safe Practices for Welding and Cutting Containers That Have Held Combustibles", A6–0–52 of the American Welding Society.

12. Hollow castings that are not vented, or castings having enclosed cavities, must not be preheated or welded until vents have been provided.

13. Do not hold torch to face to test the flow of gases.

14. Do not cut material in a position that will permit the cut section to fall on the legs, feet, hose or cylinders.

15. Arrange for good ventilation when welding on or cutting brass, bronze, galvanized iron or painted metal.

16. When welding or cutting metals containing or coated with lead, cadmium, beryllium, or mercury, always wear a suitable airline mask. Straight filter-type masks are inadequate.

17. Use particular caution when welding or cutting in dusty or gassy locations. Proceed only after the responsible official in charge has inspected the situation and has personally given instructions to proceed.

Working in Confined Spaces

1. Care should be exercised to provide sufficient ventilation at all times. All air replacing that withdrawn shall be clean and respirable. Under circumstances where it is impossible to provide such ventilation, supplied-air respirators or hose masks, approved by the U. S. Bureau of Mines for this purpose, should be used.

2. Where welding and cutting operations are carried on in confined spaces, and welders and helpers are provided with approved supplied-air respirators, or have masks for the purpose intended, a man shall be stationed on the outside of such confined space to service the ventilation lines and to insure the safety of those working within.

3. Welding or cutting in confined spaces requires special precautions. Before entering a confined space, all equipment should be tested for leaks, and regulators adjusted. Also before entering a confined space, the accumulated mixture in the hoses should be purged or blown out by opening the torch valves for a period of about 10 sec.

4. Oxygen from a cyinder or torch must never be used for ventilation.

5. Never enter a confined space with a lighted torch, or attempt to light a torch in such a space, if the odor of acetylene or other gas or vapor is detected. Some gases, when mixed with air and in contact with a spark or flame, explode with violence.

6. A man should be stationed near the cylinders prepared to shut off valves in case of emergency.

7. In case of interruption of work, all equipment should be removed from the confined space.

8. Do not blow gases into piles of waste, small stones, cinders, stacks of material, cans or other confined spaces where it may be retained and explode either at the time or later.

9. Acetylene, or a mixture of oxygen and acetylene, should never be injected into cylinders, pipe, radiators, cylinder blocks or other similar confined spaces for the purpose of lighting the torch from previously heated metal.

Fire Prevention

1. When welding or cutting by the oxyacetylene method, precautions must be taken to avoid fires. The flame itself is rarely the cause of fires, except where there is carelessness in handling. The sparks which fly when welding or cutting are globules of melted metal. They remain hot for some time and are dangerous if they alight on flammable material.

2. When it is necessary to perform welding or cutting against or near wooden structures, the structures should be protected by metal or wet asbestos, or should be wetted thoroughly.

3. When welding or cutting is being performed in buildings provided with wood floors, protect the floors from sparks or hot metal by an adequate fireproof covering. Have a fire extinguisher handy.

4. Where practical, the area in which the welding or cutting is to be done should be freed of all flammable material or rubbish. If the area cannot be cleared, a shield should be placed to stop the sparks.

5. Containers that have been, or are, filled with gasoline, oil, or flammable gas, liquid or material in the area where welding or cutting is to be done, must be removed before such work is started.

6. Wooden horses or boards should not be used to support the welding or cutting work.

7. When welding or cutting inside or immediately adjacent to a building, a fire extinguisher must be readily available. Along line of road, a fire extinguisher, water, sand, or dirt are satisfactory.

8. Whenever combustible material has been exposed to molten metal or hot slag from cutting or welding operations, a man should be posted at the site of work for a sufficient length of time after completion of the work to guard against the start of smoldering fires.

Handling and Care of Cylinders

1. Oxygen or acetylene must not be transferred from one cylinder to another. All cylinders, whether empty or full, should be kept away from stoves, radiators and other sources of heat, away from contact with electric circuits, and away from sparks or open flame.

2. Cylinders of oxygen and acetylene should be used in rotation, based on the dates received, using the oldest first.

3. The valves on empty cylinders should be kept closed.

4. Cylinders should be kept away from oil and grease.

5. When oxygen or acetylene cylinders are stored indoors, the room must be well ventilated, dry, and clear of highly combustible material, such as oil or excelsior. Cylinders should be stored in definitely assigned places where they will not be knocked over or damaged by passing objects. Acetylene cylinders should be stored with the valve end up. Oxygen cylinders should not be stored in close proximity to acetylene cylinders, unless a fire-resisting partition separates them. They should be protected from excessive rise in temperature.

6. Oxygen and acetylene cylinders may be stored in the open, but in such a case, they must be protected against extremes of temperature. During winter, cylinders stored in the open should be protected against ice and snow. Warm (not boiling) water shall be used to thaw ice in cylinder valve outlets. Cylinders stored in the open should be screened against the continuous rays of the sun in localities where extreme temperatures prevail. Cylinders containing oxygen should be stored separately from cylinders containing acetylene.

7. Cylinder valves should be protected against bumps, falls, and falling objects, and they should be kept clean. The iron caps should be in place on cylinders having them when cylinders are not in use.

8. An arc must never be struck nor an electrode tapped against a compressed-gas cylinder.

9. Acetylene cylinders should always be kept in an upright position, except when empty.

10. Cylinder valves should be opened slowly.

11. When using oxygen, the cylinder valve should be wide open to seal the clearance around the stem and prevent leakage. Wide opening of the acetylene valve is unnecessary; ordinarily it should not be opened more than 1½ turns.

12. If leaks develop in an acetylene cylinder valve around the stem, close the valve and tighten the packing gland nut. If this fails to eliminate the leak, or if the fuse plug is leaking: (1) the cylinder should be moved to open air, away from possible sources of ignition; (2) the supervisor should be notified who will arrange for safe disposition; (3) where no supervisor is readily available, the cylinder should be drained and valve

closed, and the cylinder tagged, indicating thereon the defect. Never use an open flame for detecting leaks; use soapy water.

13. When an acetylene valve is open, a valve wrench should be kept on the valve to facilitate quick closing of the valve in an emergency. Do not place anything on top of the cylinder that might interfere with quick closing of the valve or damage safety plugs.

14. Cylinders should not be handled with gloves or rags that are oily or greasy.

15. Oxygen must never be used in pneumatic tools, in oil preheating burners, to start internal combustion engines, to blow out pipelines, to create pressure in a container, nor anywhere as a substitute for compressed air or other gases.

16. If the valve on a full cylinder cannot be opened by hand, it should not be forced open. The proper supervisor should be notified, who will make necessary arrangements to return the cylinder to the supplier for necessary repairs.

17. A cylinder should never be used as a support or as a roller, or placed so as to form part of an electric circuit.

18. When transporting cylinders by crane, a cradle, platform or other suitable support should be used. A sling or an electric magnet should never be used.

19. When conveying cylinders by truck, a suitable bed or drum rack for the purpose should be used.

20. Cylinders should not be bled to empty them after all usable gas is exhausted.

21. Always use their correct names when referring to oxygen and acetylene. Never refer to oxygen as air. or acetylene as gas.

22. Never use oxygen or acetylene from a cylinder without a proper pressure-reducing regulator.

23. When cylinders are used on bridges, special care must be exercised to secure them against falling due to vibration. They must be placed so they will not be struck by passing trains.

24. Empty cylinders should be marked empty or MTY, using soapstone or chalk. They should be separated from full cylinders and returned promptly to the supplier.

25. No one shall tamper with safety devices on cylinders.

26. The numbers and markings stamped into cylinders shall not be tampered with. (Such tampering is illegal).

Handling and Care of Torches and Regulators

1. Equipment must be kept in good condition. It should be inspected before starting each day's work. No field repairs should be made to torches or regulators except to tighten packing-gland nuts on torches when leaking; if equipment is damaged or in poor condition, it should be replaced.

2. A torch should never be used to knock slag from the work. Deformation of a torch or a tip may cause trouble. A slag hammer and wire brush should be used. Torch should be shut off before being laid down for any purpose.

3. Do not allow torch to become overheated.

4. Always use the proper tip or nozzle and the proper pressure for the work involved, as shown on the apparatus manufacturer's chart.

5. Keep tips and nozzles clean. A hard, sharp tool should not be used for cleaning them, except where such a tool may be specifically recommended by or supplied by the tip or nozzle manufacturer. Use brass or copper wire, or a tip cleaner made specifically for the purpose.

6. Union nuts, connections, and all seating surfaces on regulators and torches should

be inspected before use. Damaged connections should be replaced. Regulators found with defective seats should be replaced at once.

7. Before attaching a regulator to a cylinder, the cylinder valve should be wiped out, then opened slightly for an instant, to remove any dirt present.

8. Before opening a cylinder, the regulator adjusting screw should be entirely released. A sudden rush of pressure into a regulator whose adjusting screw is turned in, puts a heavy strain on the mechanism and may cause damage.

9. Always stand to one side of and away from gage faces and front of regulator when opening cylinder valves.

10. It should be known that all connections are tight. In testing for leaks, soapy water should be used, never a flame. If necessary to tighten the union nut after the regulator is connected to the cylinder, be sure to close the cylinder valve first.

11. To adjust working pressure on oxygen and acetylene regulators:

a. *Oxygen Regulators*—With the torch oxygen valve open, turn in the pressure-adjusting screw on the oxygen regulator to the pressure desired. Then close the torch oxygen valve. In the case of cutting attachments or cutting torches, open both the torch oxygen valve and the cutting valve before adjusting the oxygen pressure. Should the cutting torch be connected to two oxygen regulators and hose lines, adjust each regulator separately with the corresponding torch valve open. Always close the torch valves after pressures are adjusted. Do not use oxygen pressures higher than those recommended by the manufacturer of the equipment.

b. *Acetylene Regulator*—With the torch acetylene valve *closed,* turn in the pressure-adjusting screw on the acetylene regulator to the pressure desired. Normal operating pressure should run from 5 to 6 lb. Under no conditions should the pressure of acetylene in the hose exceed 15 psi. Free acetylene above this pressure becomes dangerous. Open the torch acetylene valve, light the flame, and readjust the regulator to the correct pressure. Then open oxygen valve on torch and proceed with work. Precaution—never release acetylene into the air near other welding work or near sparks, flame, or any other possible source of ignition, nor into any space which is not adequately ventilated.

12. If a regulator shows excessive creep (pressure building up when torch valves are closed or torch is in use), or the pointers on the gages do not return to zero when the pressure is released, the cylinder valve should be closed and the regulator replaced.

13. Never leave pressure on regulators when they are not to be used for any considerable length of time, such as a meal period. Cut off the cylinder valves and bleed the hose lines by opening the torch valves; and then close the torch valves.

14. Unless regulators are protected, they should be removed before the welding outfit is moved.

15. The torch or hose should not be hung on a regulator or cylinder valve.

16. Standard wrenches provided for oxyacetylene equipment should be used when making connections. Oxygen connections have right-hand threads. Acetylene connections have left-hand threads.

17. When interchanging regulators of different manufacturers, a proper adapter must be used where needed.

Handling and Care of Hose

1. Hoses must not be crimped to stop the flow of gas temporarily, such as when changing torches.

2. When installing new hose or splicing hose, standard binders, clamps and hose connections must be used.

3. See that all connections are clean and free from oil or grease before connecting.

4. Always see that hoses are securely connected to torch and regulators or to welding station. All hose connections must be kept tight.

5. The size of the oxygen and acetylene hose should be that recommended by the manufacturer of the torch being used. Except under special conditions, 50-ft lengths of oxygen and acetylene hose will be used. Long lengths of hose are not desirable, as they tend to kink and to be mistreated. When long lengths are necessary, it should be known that all connections are tight and that hose is protected against being stepped on, run over, kinked or tangled.

6. Hoses should be protected against sparks, hot objects, sharp edges and open flame.

7. Hoses should be kept away from grease, oil and electric circuits.

8. All new hose is dusted inside with talc. This should be blown out before the torch is used.

9. Use only hose specially made for oxyacetylene cutting and welding. Use green hose for oxygen and red hose for acetylene.

10. Occasionally disconnect the torch and blow out hoses so that dirt or small particles of rubber will not be carried into and clog the torch passageways.

11. All hoses should be examined periodically for leaks, worn places, and loose connections. In testing for leaks, the hose should be immersed in water and normal pressure turned on one hose at a time. Leaks and worn places should be repaired at once by cutting out the defective length of hose and remaking the joints or splicing with standard fittings.

12. No attempt should be made to repair hose with tape.

13. Before lighting a torch, the hoses should be purged by opening the torch valves for about 10 sec and blowing out the accumulated explosive mixture from each hose.

14. Do not operate a torch with hoses thrown over shoulder. Keep hoses as far away from body as possible.

Backfires and Flashbacks

1. A backfire is a momentary burning back of the flame into the torch tip. It is caused by touching the tip against the work, by particles entering the tip and obstructing the gas flow, or by overheating the tip. Sometimes the trouble will clear itself immediately and, if the work is hot enough, the torch will relight automatically. If this does not happen, the oxygen torch valve should be closed immediately and the acetylene valve closed. After the pressures have been checked and found correct, the torch may be relighted, using the standard lighting procedure which includes purging the hose lines.

2. A flashback is the burning back of the flame into the tip and torch, usually with a shrill hissing or squealing, or the ignition of any explosive mixture in one of the hose lines. A flashback can, and often does, burn back into the hose. The danger in the case of a flashback can be practically eliminated by understanding immediately what it is, what it does, and what steps can be taken to remedy it. In case of a flashback, the fire should be extinguished by first closing the torch oxygen valve, then the torch acetylene valve, and then waiting a few moments to be sure the fire in the torch, or hose, has had a chance to burn out. Flashbacks can be caused by improper pressures, distorted or loose tips, defective mixer seats, kinked hose, clogged tip or torch orifices, or overheated tip or torch. The occurrence of a flashback indicates something radically wrong

with the equipment or its handling. Before attempting to relight a torch, a check should be made to determine if the flashback was caused by improper pressure, distorted or loose tips, kinked hose, clogged tip, or overheated tip or torch. Also, the hose should be inspected for damage. If the flame has burned back into the hose, the hose should be cut back to the undamaged portion and a new connection made with a standard clamp device or replaced altogether. If damaged, the torch, tip and regulators should be replaced.

Shutting Down on Line of Road

1. When shutting down for lunch, or for a period of similar length, the following should be done:

a. Hoses and torch should be so placed that they cannot be damaged.
b. Close cylinder valves.
c. Drain hoses and torch.
d. Close the torch valves.

2. When shutting down at the end of the working day, or for other extended periods, the following should be done:

a. Close cylinder valves.
b. Drain hoses and torch.
c. Turn adjusting screw on regulators to left until all pressure is removed.
d. Close the torch valves.
e. Remove hose from regulators.
f. Coil hose.
g. Remove regulators from cylinders.
h. Place caps on cylinders.
i. Remove all equipment, except cylinders, to tool car or other safe place.

Oxygen and Acetylene Supplied From Pipe Lines, Manifolds, Generators, Etc.

Oxygen Supplied from a Portable Manifold

1. Use only an approved oxygen manifold.

2. Before attaching cylinders to manifold leads, the cylinder valves should be wiped out, then opened slightly for an instant to remove any dirt present.

3. Connect the cylinders to the leads of the manifold or coupler units. Attach the oxygen pressure-reducing regulator to the manifold block or to the one coupler connection that is open. Turn out the pressure-adjusting screw until all the pressure is released.

4. Open one cylinder valve—slightly at first—then all the way. Then open all the valves fully. Precaution—Always stand to one side and away from gage faces, and from in front of the regulator when opening the cylinder valves.

5. Connect the hose to the pressure-reducing regulator. Connect the loose end of the hose to the torch connection marked oxygen.

6. At the end of each work period, the supply valve should be closed.

Oxygen Supplied from a Distribution Line

1. Before connecting the station oxygen pressure-reducing regulator to the outlet of the station valve, the outlet to the station valve should be wiped out, then opened slightly for an instant to remove any dirt present.

2. Attach the station oxygen pressure-reducing regulator to the outlet of the station valve. Turn out the pressure-adjusting screw until all the pressure is released.

3. Open the station valve—slightly at first—then all the way.

4. Connect the hose to the pressure-reducing regulator. Connect the loose end of the hose to the torch connection marked oxygen.

5. At the end of each work period, the supply valve should be closed. Note—If the oxygen for a distribution line is furnished by manifold cylinders, the same procedure and safety precautions will be used as for connecting up a portable manifold shown under "Oxygen Supplied from a Portable Manifold", above.

If oxygen for a distribution line is furnished by a "cascade" system, the receivers, pressure-regulating valves, etc., of the "cascade" system will be owned by the supplier of the oxygen and not by the railroad. The supplier's instruction for the care and operation of the "cascade" system shall be followed.

Acetylene Supplied from a Portable Manifold

1. Use only an approved acetylene manifold.

2. Before attaching cylinders to manifold leads, the cylinder valves should be wiped out, then opened for an instant to remove any dirt present.

3. Connect the cylinders to the manifold leads or coupler units. There should be a flash arrester between each lead and cylinder valve. Attach an acetylene pressure-reducing regulator to the manifold block or to the one coupler connection that is open. Turn out the pressure-adjusting screw until all the pressure is released. If the threads on the cylinders do not match the threads on the manifold leads, first connect the proper adaptor to each cylinder valve, and then connect the lead to the adaptor.

4. Open one cylinder valve—slightly at first—then one and one-half turns, but no more. Similarly, open all cylinders.

5. Connect the hose to the pressure-reducing regulator. Connect the loose end of the hose to the torch connection marked acetylene.

6. At the end of each work period, the cylinder valves should be closed.

Acetylene Supplied from a Portable Generator

1. Make sure the hydraulic back-pressure valve is filled to the proper level with liquid.

2. Before attaching the hose to the outlet on the back pressure valve, the outlet should be wiped out and the back pressure valve opened for an instant to remove any dirt present.

3. Connect the hose to the outlet on the back-pressure valve. Connect the loose end of the hose to the torch connection marked acetylene. Turn on the back-pressure valve.

4. At the end of each work period, the supply line should be closed.

Note—The manufacturer's instructions for the care and operation of a portable generator must be followed.

Acetylene Supplied from a Distribution Line

1. If the line is equipped with station hydraulic backpressure valves, proceed as in the case of "Acetylene Supplied from a Portable Generator", above.

2. If the line is not equipped with a station hydraulic backpressure valve, a station acetylene regulator should be installed at each station.

3. Before attaching the station regulator, the station valve outlet should be wiped out and the station valve opened for an instant to remove any dirt present.

4. Attach an acetylene station pressure-reducing regulator to the station valve. Turn out the pressure-adjusting screw until all the pressure is released.

5. Connect hose to the regulator. Connect the loose end of the hose to the torch

connection marked acetylene on the torch. Open the station valve and turn in the pressure-adjusting screw until the desired pressure is obtained.

6. At the close of each work period the supply valve should be closed.

Note—If the acetylene for a distribution line is furnished by manifolded cylinders, the same procedure and safety precautions will be used as for connecting up a portable manifold shown under "Acetylene Supplied from a Portable Manifold", above. If acetylene for a distribution line is furnished by an installed generator, the instructions furnished by the manufacturer of the equipment shall be followed.

PART 2—ELECTRIC-ARC WELDING AND CUTTING

Only those men qualified by the welding inspector, supervisor, or instructor, should be assigned to welding or cutting. Helpers or trainees may perform certain welding and cutting under the direct supervision of a qualified welder.

Electric-Arc Welding and Cutting Equipment

Personal Safety

1. Handle electric welding and cutting equipment with caution. Any voltage used in connection with electric welding is safe if properly handled. Almost any voltage may be hazardous if equipment is improperly or carelessly handled.

2. Avoid shock. This is especially hazardous when body is damp or wet. Never let live metal parts of electrode holder or welding cable touch the skin.

3. Do not stand in water or damp places while welding, except when provided with waterproof, insulated footwear.

4. The frame or case of a welding machine (except engine-driven machines) shall be grounded under the conditions and according to the methods prescribed in the National Electric Code, American Standard C1–1956, Art. 250, for fixed or portable electrical equipment.

5. Open-Circuit (no-load) voltages of arc welding machines should be as low as possible, consistent with satisfactory welding of the type being done. The following limits shall not be exceeded:

a. For manual-shielded metal-arc welding:
   (1) Single-operator d-c welding machine—100 v.
   (2) Constant-potential multiple-operator d-c welding machines—80 v.
   (3) A-c welding machines—80 v.

b. For a-c welding under wet conditions or warm surroundings where perspiration is a factor, the use of reliable automatic controls for reducing no-load voltage is recommended.

6. Men engaged in arc welding must wear an approved type of helmet or use an approved type of hand shield arranged to protect the eyes, face, neck and ears from the rays of the arc. They should also wear clear goggles to protect the eyes against flying scale when the weld metal is cooling or being peened.

7. Care should be taken to avoid getting sparks in pockets of clothing. Shirt sleeves should be rolled down and shirt buttoned. Trousers should be without cuffs. Woolen clothing is preferable to cotton because it is not as readily ignited. Protective clothing should be worn by men actually engaged in the welding operation when the nature of the work makes it necessary. Gloves must be worn by men actually engaged in the welding operation.

8. A suitable screen marked "Do Not Look at Arc" should be set up at the welding site to shield those not actually engaged in the operation against the rays of the arc.

9. Men not actually engaged in the welding operation, but who must perform work near it, must not watch the arc. If the nature of the work does not permit proper screening, they must wear an approved type of goggles with a lens that will provide protection for the eyes.

10. When practical, debris and flammable material should be cleared from the area (25 ft) before welding. The electric arc and sparks should be kept away from all welding equipment.

11. Special care should be taken when working on staging suspended by rope to prevent damaging or setting fire to the rope.

12. Tanks and containers that are known to have, or which possibly could have, contained flammable gases or liquids must not be welded or cut on by electric arc, except when cleaned and welded or cut in accordance with "Safe Practices for Welding and Cutting Containers that Have Held Combustibles", A6–0–52 of the American Welding Society.

13. An arc must never be struck, nor an electrode tapped against a compressed-gas cylinder.

14. Hollow castings that are not vented, or castings having enclosed cavities, must not be preheated or welded until vents have been provided.

15. Arrange for good ventilation when welding on or cutting brass, bronze, galvanized iron, or painted metal.

16. When welding or cutting metals containing or coated with lead, cadmium, beryllium or mercury, always wear a supplied-air respirator or mask. Filter-type masks are inadequate. Inert-gas metal-arc cutting of stainless steel shall be done under mechanical ventilation adequate to remove the fumes generated.

17. Use particular caution when welding or cutting in dusty or gassy locations. Proceed only after the responsible official in charge has inspected the situation and has personally given instructions to proceed.

18. When operating a gas- or diesel-driven generator inside a car, building or other enclosed space at any time, suitable means must be provided for disposing of exhaust fumes to the outside air.

Working in Confined Spaces

1. Care should be exercised to provide sufficient ventilation at all times. All air replacing that withdrawn shall be clean and respirable. Under circumstances where it is impossible to provide such ventilation, supplied-air respirators or hose masks, approved by the U. S. Bureau of Mines for this purpose, should be used.

2. Where welding and cutting operations are carried on in confined spaces, and welders and helpers are provided with approved supplied-air respirators, or have masks for the purpose intended, a man shall be stationed on the outside of such confined space to service the power and ventilation lines and to insure the safety of those working within.

3. Welding or cutting in confined spaces requires special precautions. Before entering confined spaces, electrode holders and cables should be inspected to see that they are properly insulated.

4. Oxygen from a cylinder or torch must never be used for ventilation.

5. Never attempt to weld or cut in a confined space in which the odor of acetylene

or other gas or vapor is detected. Some gases when mixed with air and in contact with a spark or flame, explode with violence.

6. In case of interruption of work, all welding equipment should be removed from the confined space.

Fire Prevention

1. When welding or cutting by the electric-arc method, precautions must be taken to avoid fires. The arc itself is rarely the cause of fires, except where there is carelessness in handling. The sparks which fly when welding or cutting are globules of melted metal. They remain hot for some time and are dangerous if they alight on flammable material.

2. When it is necessary to perform welding or cutting against or near wooden structures, the structures should be protected by metal or wet asbestos, or wetted thoroughly.

3. When welding or cutting is being performed in buildings provided with wood floors, protect the floors from sparks or hot metal by an adequate fireproof covering. Have a fire extinguisher handy.

4. Where practical, the area in which the welding or cutting is to be done should be cleared of all flammable material or rubbish. If the area cannot be cleared, a shield should be placed to stop the sparks.

5. Containers that have been, or are, filled with gasoline, oil, or any flammable gas, liquid or material in the area where welding or cutting is to be done, must be removed before such work is started.

6. Wooden horses or boards should not be used to support the welding or cutting work.

7. When welding or cutting inside, or immediately adjacent to, a building, a fire extinguisher must be readily available. Along line of road, a fire extinguisher, water, sand, or dirt are satisfactory.

8. Whenever combustible material has been exposed to molten metal or hot slag from cutting or welding operations, a man should be posted at the site of work for a sufficient length of time after completion of the work to guard against the start of smoldering fires.

General

1. Welding current preferably should be returned to the welding machine by a single cable from the work to the welding machine.

2. Conduits containing electrical conductors shall not be used for completing a welding circuit. Pipelines shall not be used as a permanent part of a welding circuit, but may be used during construction, extension or repair, provided current is not carried through threaded joints, flanged bolted joints, or caulked joints, and the pipe does not contain flammable substances.

3. Chains, wire ropes, cranes, hoists and elevators shall not be used to carry welding current.

4. Never make a welding ground connection in such a way that welding current will pass through a machine bearing of any type.

5. When during construction or modification, a building or any other fabricated metal structure is used for a welding-current return circuit, it should be checked to make sure that proper electrical contact exists at all joints. If not, corrective measures should be taken.

6. When a structure, conveyor or fixture is regularly employed as a welding-current return circuit, joints shall be bonded or provided with adequate current-collecting devices,

and periodic inspections should be conducted to see that no condition of electrolysis or shock or fire hazard exists by virtue of such use.

7. In operations involving several welders on one structure, care should be taken to eliminate the possibility of welders touching two electrode holders simultaneously. If this cannot be done, machines shall be connected as follows:

a. All d-c machines shall be connected to the same polarity.

b. All a-c machines shall be connected to the same phase of the supply circuit and with the same instantaneous polarity.

8. When it becomes necessary to carry cables some distance from the machines, they should be substantially supported overhead. If this cannot be done, and cables are laid on the floor or ground, they should be protected in such a manner that they will not be damaged, entangled, or interfere with safe passage. Special care should be taken to see that welding supply cables are not in close proximity to power supply cables or other high-tension wires.

9. There shall be no leaks of torch cooling water or arc shielding gas.

10. Printed rules and instructions covering operation of the equipment, including those of the manufacturer, shall be strictly followed.

11. When the welder has occasion to leave his work or stop work for any appreciable time, the welding machine should be stopped, or the power supply switch to transformers or rectifier welders should be opened.

12. Metal and carbon electrodes should be removed from holders when not in use, to eliminate the danger of electrical contact with persons or conducting objects. Tungsten electrodes should be removed or retracted within holders. Electrodes in wire form in semi-automatic holders should be retracted or cut off to remove the possibility of contact. Electrode holders, when not in use, shall be so placed that they cannot make electrical contact with persons, conducting objects, fuel or compressed-gas tanks.

13. Periodic inspections shall be made to be sure that all arc welding equipment is maintained in safe working order at all times. The operator shall report any equipment defect or safety hazard to his supervisor, and the use of the equipment shall be discontinued until his safety has been assured. Repairs shall be made only by persons who are qualified and authorized to do so.

14. Welding equipment used in the open should be protected from inclement weather conditions. Machines that have become wet shall be thoroughly dried and tested before being used. Protective cover shall not obstruct the ventilation necessary to prevent overheating of the machine.

15. When necessary that the equipment be stored, it should be stored in a clean, dry place.

16. Welding machines not equipped with meters should be checked frequently to insure proper operation.

17. The ground clamp should be attached to the work as close to the welding as practicable. In the case of insulated rail joints, the ground must be on the rail end on which the welding is being done. On non-insulated joints, the ground should preferably be on the same rail end as that on which welding is being done. Special precautions must be taken when welding rails carrying track circuits to prevent an arc from being struck on any rail other than the rail on which ground is located.

18. Changing polarity, or throwing rotary switch when machine is under load, is prohibited.

Handling and Care of Cables

1. Welding cables should be kept dry, where practical, and free from grease and oil.

2. Exercise care to prevent damage to cable and connector plugs by rough handling, or by dropping tools or other objects, especially hot objects and sparks, on them.

3. When moving a cable, it should not be dragged over rough or sharp surfaces. Strains at connections and terminals are particularly to be avoided.

4. Where possible, the cable should be kept straight while in use, instead of coiled, twisted or kinked.

5. Deep cracks or cuts in the casing of a cable should be repaired promptly; otherwise the insulation will be damaged and the cable rendered unfit for further service. Cable with damaged insulation should not be used.

6. When the cable is spliced, the conductor joints should be soldered. Insulation and jacket compounds that cover the joints should be vulcanized, if possible.

7. Power-supply cables must contain the proper number of conductors and should preferably include the ground wire. They must be of sufficient size and have proper insulation in accordance with the National Electrical Code.

8. Only an approved type of welding cable should be used.

9. When welding-cable extensions are necessary, substantial insulated connectors of the locking type should be used.

10. Cable sizes for welding operations should never be less than those given below, and for long lengths of cable, larger sizes will be necessary.

Recommended Minimum Cable Sizes

Welding Current Amps.	*Minimum Cable Size* Copper *No.*	Aluminum *No.*
100	4	4
150	3	2
200	2	0
250–300	1/0	3/0
300–450	2/0	
500	3/0	
600	4/0	

11. Overloading welding cables is prohibited.

12. It is preferable to employ continuous lengths of cable from the holder to the machine. This practice is usually satisfactory if cable lengths do not exceed 35 ft and a good grade of extra-flexible cable is used. In most cases, it is desirable to insert a length of extra-flexible cable near the holder. In no case should a cable splice be permitted within 10 ft of the holder

13. When not in use, electric cable should be stored in a dry, cool place. It should be loosely coiled, with no sharp kinks or bends, away from direct sunlight, grease and oil. If particularly dirty or greasy, it should be cleaned before it is stored. In cleaning, gasoline or other rubber-soluable materials should not be used.

Electrode Holders

1. Use only an approved electrode holder.
2. Electrode holder should preferably be of a type with insulated jaws.
3. Keep holding jaws clean to avoid arcing.
4. Electrode holders must not be cooled by immersion in water.
5. Handle carefully to prevent damage.

6. See that the cable is securely fastened to the holder. If the holder heats excessively with rated current, check cable connection.

Ground Clamps or Magnetic Grounds

1. Contact faces of ground clamps and magnetic grounds must be kept clean. Clamps and magnetic grounds must be securely fastened to the cable.

2. Ground clamps or magnetic grounds must make secure electrical contact with material to be welded.

Electrode Receptacle

1. Use an electrode receptacle of suitable design for the type of work to be done to preserve and protect the electrodes.

2. Remove coated electrodes from original containers only as used. Unused low-hydrogen electrodes should be returned to original containers and sealed at the end of each day's work.

Welding Helmets and Hand Shields

1. Helmets and hand shields must be handled carefully to prevent damage.

2. Helmets or hand shields with pin holes in them, or broken or cracked lenses, shall not be used.

3. Cover glass should be provided to protect the lens of each helmet or hand shield.

4. Lenses shall bear some permanent distinctive marking by which the source and shade may be readily identified.

5. The following table is a guide for the selection of the proper shade numbers. These recommendations may be varied to suit the individual's needs.

Welding Operation	*Shade Number*
Shielded metal-arc welding, $\frac{1}{16}$-, $\frac{3}{32}$-, $\frac{1}{8}$-, $\frac{5}{32}$-in electrodes	10
Inert-gas metal-arc welding (nonferrous) $\frac{1}{16}$-, $\frac{3}{32}$-, $\frac{1}{8}$-, $\frac{5}{32}$-in electrodes	11
Inert-gas metal-arc welding (ferrous) $\frac{1}{16}$-, $\frac{3}{32}$-, $\frac{1}{8}$-, $\frac{5}{32}$-in electrodes	12
Shielded metal-arc welding $\frac{3}{16}$-, $\frac{7}{32}$-, $\frac{1}{4}$-in electrodes	12
$\frac{5}{16}$-, $\frac{3}{8}$-in electrodes	14
Carbon-arc welding	14

Shutting Down

1. When shutting down for lunch, or for a period of similar length, the following should be done:

a. Gasoline- and diesel-engine-driven welders:
   (1) Allow engine to run at idling speed for several minutes.
   (2) Stop engine.
   (3) Place cable where it will not be damaged.
   (4) Place electrode holder where it will not be damaged or the electrode start an arc on starting up machine.

b. Portable and permanently installed electric-driven welding machines:
   (1) Open switch on welder or the switch nearby that controls welder.
   (2) Place cable where it will not be damaged.
   (3) Place electrode holder where it will not be damaged or the electrode start an arc on starting up machine.

2. When shutting down at the end of the working day, or for other extended periods, the following should be done:

a. Gasoline and diesel-engine-driven welders:
   (1) Allow engine to run at idling speed for several minutes.
   (2) Stop engine.
   (3) Shut off valve from fuel tank.
   (4) Refill fuel tank (unless tank is to be drained for shipment.)
   (5) If the engine has a vertical exhaust pipe with an open end, the open end must be covered.
   (6) If the engine has an automatic weather cap, welder must see that it is closed.
   (7) Remove and coil cables.
   (8) Remove all equipment, except welding machine, to tool car or other safe place.
   (9) Close up or cover welding machine, as required.

b. Portable electric-driven welder:
   (1) Open switch on machine, or switch nearby that controls welder.
   (2) Open switch at receptacle for the machine.
   (3) Remove cables.
   (4) Coil cables.
   (5) Remove all equipment except welding machine, to tool car or other safe place.
   (6) Cover up welding machine with tarpaulin or other suitable cover.

c. Permanently installed electric-driven welder:
   (1) Open switch on machine, or switch nearby that controls welder.
   (2) Open main switch for welder.
   (3) Place cables where they will not be damaged.
   (4) Place electrode holder where it will not be damaged, or the electrode start an arc on starting up.

Care and Operation of Gasoline and Diesel Engines Driving Welding Generators

Gasoline and diesel engines shall be operated and maintained in accordance with the current issue of the AREA Handbook of Instructions for Care and Operation of Maintenance of Way Equipment, and manufacturers' instructions.

Care and Operation of Electric Motors Driving Welding Generators

Electric motors driving welding generators shall be maintained in accordance with the current issue of Standard and Recommended Practice of Lubrication of Motors and Inspection and Maintenance of Electrical Equipment, Electrical Section, Operations and Maintenance Department, Association of American Railroads.

Care and Operation of Welding Generators

1. Care must be taken to prevent overloading the welding generator. It must not be operated above its current rating and corresponding rated duty cycles, as specified by the manufacturer.

2. Manufacturers' recommendations for greasing should be followed. Do not overgrease.

3. The tension on brushes should be equal, and the brushes should fit in their holders so they are free to move without sticking or binding, but not so loose that they chatter or get out of alinement.

4. A frequent cause of generator trouble is an accumulation of oil and dirt on brushes, brushholders and commutators. The interior of a generator should be cleaned by suction, or by blowing out with low-pressure compressed air, or a hand bellows, making sure that the air is free from moisture A moisture-soaked generator should be dried out thoroughly before it is operated.

5. Commutators, brushes, and brush holders should be cleaned with a lint-free clean cloth. If these parts are unusually dirty or sticky, the cleaning may be done with a suitable solvent cleaner such as trichloroethylene while the generator is at rest.

6. If the ammeter or voltmeter does not operate properly, the connections at the brushes, brush holders or the leads to the ammeter and voltmeter should be examined.

7. If the commutator becomes rough or grooved, it should be smoothed with a commutator cleaning stone. No. 00 sandpaper may be used if a stone is not available. Never use emery cloth or emery paper. After cleaning, the dust should be blown away.

8. If there is evidence of excessive sparking, the cause should be located and corrected at once. Sparking may be caused by one or more of the following:

a. Rough, flat, or high spots on th commutator surface.
b. Brushes not moving freely in brushholders.
c. Insufficient brush tension.
d. Excessive load, voltage or vibration.
e. Open-circuited or short-circuited armature and field windings.
f. Accumulation of carbon or dirt in the undercut slots.
g. Dirty or glazed brushes or dirty commutator.
h. Brushes not in correct position.
i. Poor face on brushes, if replacement brushes have just been installed.
j. Whipping armature.
k. Defective bearings.

Rectifier-Type Welders

1. Rectifier-type welders require very little attention.

2. Keep welder clean and dry.

3. Inspect occasionally to determine that all the equipment is clean and in good condition.

4. Blow out dust and dirt with clean, dry air, as conditions require.

Note—Do not open machine until disconnect switch has been opened on both welding machine and power supply line.

A–C Type Welders

1. A-c type welders require very little attention.

2. Keep welder clean and dry.

3. Inspect occasionally to determine that all the equipment is clean and in good condition.

4. Blow out welder with clean, dry air as often as conditions require.

Note—Do not open machine until disconnect switch has been opened on both welding machine and power supply.

Spot and Seam Welders, Hand Guns and Automatic Guns

These types of welders require very little maintenance. They should be operated and maintained in accordance with each individual manufacturer's instructions.

PART 3—OPERATING GRINDING EQUIPMENT

Only those men qualified by the welding or grinding inspector, supervisor, or instructor, should be assigned to operate grinding equipment. Helpers or trainees may perform certain grinding under the direct supervision of a qualified grinding-machine operator. The operation of grinding equipment is safe if properly handled. Under certain unsatisfactory conditions, a grinding wheel may break or fly to pieces. The following instructions are designed to safeguard a grinding-machine operator, and it is in the interest of his own personal safety to see that unsatisfactory conditions do not exist.

Grinding Equipment

Personal Safety and Fire Prevention

1. While operating a grinding wheel, the operator must wear protective dust-proof goggles. Where conditions require their use, gloves and respirators should be worn. Wheels must be equipped with protection hoods or guards, including those on grinding attachments.

2. The frame or case of electric grinders shall be grounded under the conditions and according to the methods prescribed in the National Electric Code, American Standard C1–1956, Art. 250, for fixed or portable electrical equipment.

3. Care should be taken to avoid getting sparks in pockets of clothing. Trousers without cuffs, and other protective types of clothing should be worn by men engaged in grinding operations.

4. Where practical, flammable material should be cleared from the work area before grinding operations are begun, and sparks should be kept away from gasoline engines.

5. Adequate ventilation should be provided when grinding on brass, bronze or galvanized iron. When grinding on metals containing or coated with lead, cadmium, beryllium, or mercury, always wear a supplied-air respirator or mask. Filter-type masks are inadequate for this type of grinding.

6. Extreme caution must be observed when grinding at dusty or gaseous locations. Grinding under such conditions must not be started until a supervisory officer has made an inspection and gives instructions to proceed with the work.

7. When operating an engine-driven generator inside a car, building or other enclosed space at any time, suitable means must be provided for disposing of exhaust fumes to the outside air.

8. Extreme care must be exercised when grinding in confined spaces.

9. Proper precautions must be taken to avoid fires. Grinder sparks remain hot for some time and should not be permitted to alight on combustible materials.

10. When necessary to perform grinding against or near wooden structures, the parts of the structure on which sparks may fall should be thoroughly wetted or protected by metal shields or wet asbestos.

11. When grinding in buildings with wooden floors, the floors should be protected against sparks, and a fire extinguisher should be readily available.

12. No persons, except the grinding machine operator or his helper, should stand near a grinder during its operation. and neither of these men should stand in line with the grinding wheel, except as necessary to perform their work.

13. Grinding wheels should be stopped, if practical, or slowed down while a grinding machine is being moved. In moving a grinder, care must be taken to see that the wheel does not strike anything that might damage it.

14. Thin grinding wheels, such as those used for slotting, may break under excessive

side pressure, and precautionary measures should be taken to see that such wheels are not used incorrectly.

15. Work rests, where used, must be kept in proper adjustment, with a maximum distance of ⅛ in between the wheel and the rest, to prevent the object being ground from becoming lodged in this open space. Work-rest adjustments must not be made while the wheel is running, and the rest should be securely clamped after the adjustment.

Portable Grinding Machines

1. Lubricate bearings in rollers and all other moving parts, except countershaft, daily. Wipe off grease fittings before lubricating. Wipe off all excess grease. Do not grease tracks or outside of rollers.

2. The countershaft has two ball bearings. Inject a small amount of high-speed ball-bearing grease in these bearings every 50 hr. Do not overlubricate.

3. Inspect the grinder each day. See that the protection hood or guard is properly adjusted and that all bolts are tight. Do not operate without an approved protection hood or guard.

4. Drive belts must be kept in proper adjustment. Clutches must be kept in good working order and properly adjusted at all times.

5. Add several drops of oil once each month to the clutch to provide the small amount of lubrication required and to avoid rusting.

6. On engine-driven grinders the speed of the grinding wheels should be checked by a tachometer or speed counter often enough to insure that the governor is operating properly and has not been tampered with. Only authorized persons should attempt to repair or replace the governor.

7. All electric motors and internal-combustion engines should be operated and maintained according to manufacturer's recommendations.

Flexible Shaft

1. Keep flexible shaft as straight as possible during working operation. This can be accomplished on machines having turntable by unlocking the spring stop on the turntable, allowing the engine to pivot or follow the operator and thereby more or less eliminate the possibility of a sharp bend in the flexible shaft, which might cause damage to it. Avoid sharp bends or kinks in the flexible shaft.

2. The flexible shaft should be lubricated consistent with hours of service, not to exceed 50 hr, with a good grade of grease. To lubricate the shaft, disconnect it from the machine and pull out the core. Wipe off old lubricant from the core. While slipping the core back into the casing, take lubricant in hand and apply a fairly good coating of it around the core for its entire length as it goes in. Do not overlubricate. During the lubricating operation make sure that the core is kept clean. Use only lubricant that is free from grit and dirt.

3. When left on the machine with attachments removed, the open end should be covered with a clean rag. Also, the attachment on the engine or motor should be covered with a clean rag when the flexible shaft is removed.

4. When flexible shafts are removed from grinders for storage, the ends should be covered with clean rags. The shaft should be stored in a straight position.

Auxiliary Attachments for Flexible-Shaft Grinders—Gas and Electric

1. Surface-grinding attachments, cross-grinder attachments, spindle hand pieces and other attachments for flexible shafts contain ball bearings, which must be kept clean and properly lubricated at all times.

2. The bearings should be lubricated with a good grade of high-speed ball-bearing grease about every 50 hr of operation. Do not overlubricate.

3. The grinding attachments must be equipped with an approved protection hood or guard.

4. The attachments should be inspected each day to determine if the equipment is in safe working condition.

5. When an attachment is removed the dirt protection cap or plug, if provided, should be applied; otherwise, use a clean rag to cover the connection opening in the attachment.

Portable Electric Hand Grinders

1. The frame or case of a portable electric hand grinder shall be grounded under the conditions and according to the methods prescribed in the National Electrical Code, American Standard C1–1956, Art. 250, for fixed or portable electrical equipment.

2. Keep attachment cord free from grease and oil.

3. Switch and attachment plug or body should be inspected periodically to determine if they are in safe working condition. They should be repaired immediately if in need of repair.

4. Connecting and extension cords should be inspected periodically. Any break in insulation should be repaired immediately, preferably by vulcanizing.

5. Grinder must be equipped with an approved protection hood or guard which must be kept in place and in good repair.

6. Manufacturer's instructions should be followed in lubricating. Do not overlubricate.

Bench, Floor-Stand and Swing-Frame Grinders—Electric

1. The frame or case of a bench, floor-stand or swing-frame grinder shall be grounded under the conditions and according to the methods prescribed in the National Electrical Code, American Standard Code C1–1956, Art. 250, for fixed or portable electrical equipment.

2. The grinder must be equipped with an approved protection hood or guard. Work rests on bench and floor-stand grinders, if so equipped, shall be kept adjusted to the wheel to a maximum distance of ⅛ in to prevent the work being caught between the wheel and the rest.

3. The grinders should be inspected periodically to determine if the protection hood or guard and work rest, if any, are tight and properly adjusted and that the grinder is in safe working condition.

4. Manufacturer's instructions should be followed for lubricating. Do not overlubricate.

Portable Hand Air Grinders

1. Grinder must be equipped with an approved protection hood or guard which must be kept tight and properly adjusted.

2. Only approved types of couplings and air hose should be used.

3. Grinder should not be used at an air pressure higher than that for which the grinder is intended.

4. Water should be blown from the air line before starting each day's work.

5. Air-line oilers are desirable to assist in lubricating grinders.

6. Speed of grinder should be checked periodically by a tachometer or speed counter

to determine if the speed of the grinder is correct. Only authorizd persons should attempt to repair or replace the grinder.

7. Manufacturer's instructions should be followed for lubricating.

Use and Care of Abrasive (Grinding) Wheels[1]

Spindles

1. Spindles shall not be smaller than shown in Table 1 for overhung wheels nor smaller than shown in Table 2 when wheel is mounted on spindle between bearings.

2. If wheels have threaded nuts or are mounted by means of a central spindle nut, the direction of the thread shall be such in relation to the direction of rotation that the nut will tend to tighten as the spindle revolves. On double-end floor-stand and bench grinders, one end of the spindle must, therefore, have a right-hand thread and the other a left-hand thread.

3. If wheels are mounted by means of a central spindle nut and flanges, the spindle should be of sufficient length and should be threaded to a sufficient length so that when the wheel and flanges are mounted there will be room for a full nut on the spindle, and the threading should extend well inside the flange or washers shall be placed between the outer flange and the nut.

4. Grinding wheels larger than recommended by the manufacturer of the machine for the size of the spindle must not be used.

5. Approved flanges must be used with all grinding wheels.

6. The driving flange should be keyed, screwed, shrunk, pressed or otherwise secured to the spindle, and the bearing surface should run true with the spindle.

Inspection of Grinding Wheels

1. Before mounting, a grinding wheel should be given a close inspection to make sure that it has not been damaged. The wheel should be suspended by holding it between the thumb and forefinger and tapping it gently with the handle of a screw driver or hammer handle. If the wheel is sound, it will have a clear ring; if cracked, or damp, it will have a dull sound. Wheels must be free from sawdust, excelsior, or other foreign matter when tested; otherwise, the sound will be deadened. Defective wheels should be destroyed immediately.

2. If a grinding wheel should break during its operation, a careful inspection should be made to insure that the hood, flanges, and nuts have not been damaged, and that the spindle has not been bent or sprung out of balance.

3. Wheels out of balance through wear, which cannot be balanced by truing or dressing, must be destroyed.

4. Grinder operators should periodically inspect grinding wheels that are in use and report to their supervisory officer anything unusual in the operation of the grinder, such as peculiar noises, apparent increase in engine or spindle speed, vibration, wheel out of balance or badly worn, etc.

Handling of Grinding Wheels

1. All grinding wheels are breakable, and some are very fragile. Extreme care must be exercised in handling and storage to prevent damage which might cause a wheel to fly apart when brought up to speed The following rules, which are based on experience, shall always be observed:

a. Handle wheels carefully to prevent dropping or bumping.

b. Do not roll grinding wheels (hoop fashion).

[1] Based on American Standards Safety Code for the Use, Care and Protection of Abrasive Wheels, Publication ASA B7.1—1956 published by the American Standards Association, 70 East 45th Street, New York 17.

TABLE 1—MINIMUM DIAMETERS OF MACHINE SPINDLES AT POINT OF MOUNTING FOR OVERHUNG WHEELS OF VARIOUS DIAMETERS AND THICKNESSES OPERATING AT SPEEDS UP TO 9,500 PERIPHERAL FEET PER MINUTE

Diameter of Wheel	Thickness of Wheel, Inches																		
	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	4	4 1/2	5
	Diameter of Spindle—Inches																		
2	1/8	5/16	3/16	1/4	1/4	3/8	------	------	------	------	------	------	------	------	------	------	------	------	------
3	1/4	1/4	3/8	3/8	3/8	3/8	------	------	------	------	------	------	------	------	------	------	------	------	------
4	5/16	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2	------	------	------	------	------	------	------	------	------
5	3/8	3/8	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	------	------	------	------	------	------	------	------	------
6	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	1
7	1/2	1/2	1/2	1/2	1/2	1/2	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	1	1	1
8	1/2	1/2	1/2	1/2	5/8	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	1	1	1	1	1	1
9	5/8	5/8	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	1	1	1	1	1	1	1 1/4	1 1/4	1 1/4
10	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4
12	3/4	3/4	3/4	3/4	3/4	3/4	3/4	1	1	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2
14	3/4	3/4	3/4	3/4	1	1	1	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2
16	------	------	------	------	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4
18	------	------	------	------	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4
20	------	------	------	------	------	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 3/4	2
24	------	------	------	------	------	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 3/4	2	2	2
26	------	------	------	------	------	------	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 3/4	2	2	2	2	2
30	------	------	------	------	------	------	------	1 3/4	1 3/4	1 3/4	1 3/4	1 3/4	2	2	2	2	2 1/4	2 1/4	2 1/4
36	------	------	------	------	------	------	------	------	2	2	2	2	2 1/4	2 1/4	2 1/4	2 1/2	2 1/2	2 3/4	2 3/4

Note: For speeds exceeding 9,500 peripheral feet per minute and for wheels with heavy mountings, (such as bolted-on abrasive discs) the spindle sizes shown in the above table are usually not adequate. Inasmuch as the proper spindle size is dependent upon many factors, such as general design of the machine, type of bearings, quality of materials and workmanship, a simple table is not practicable. Wheels larger than specified by the machine manufacturer should not be used on any given machine.

TABLE 2—MINIMUM DIAMETERS OF MACHINE SPINDLES AT POINT OF MOUNTING FOR WHEELS OF VARIOUS DIAMETERS AND THICKNESSES MOUNTED BETWEEN BEARINGS AND OPERATING AT SPEEDS NOT EXCEEDING 5,000 PERIPHERAL FEET PER MINUTE

Wheel Diameter Inches	*Wheel Thickness Inches*	*Distance between Bearings (Inches)*		
		18	*Over 18 to 24*	*Over 24 to 30*
		Inches	*Inches*	*Inches*
36	3 and thinner	1 3/4	1 7/8	2
	3 1/8 to 6	1 7/8	2	2 1/8
	6 1/8 to 8	2	2 1/8	2 1/4
48	3 and thinner	2	2 1/8	2 1/4
	3 1/8 to 6	2 1/8	2 1/4	2 1/2
	6 1/8 to 10	2 1/2	2 3/4	3
60	3 and thinner	2	2 1/4	2 1/2
	3 1/8 to 6	2 1/2	2 3/4	3
	6 1/8 to 10	2 3/4	3	3 1/4

c. Tools, material, or other objects should not be piled on grinding wheels.

d. Grinding machines should be handed carefully to insure that the grinding wheel is not damaged.

2. Grinding wheels absorb moisture and should be protected against it where possible.

3. Grinding wheels should be left in the container in which received until used, and stored in a dry place.

Mounting of Grinding Wheels

1. When mounting a grinding wheel, care must be taken to see that the protection guard or hood is correctly replaced.

2. Grinding wheels must fit freely on the spindle and must not be forced on. A wheel with a hole too large to fit properly on the spindle must not be mounted unless a correct-size bushing is used.

3. Wheels that have absorbed water should not be used until thoroughly dry, because the weight of the water may unbalance the wheel.

4. The soft-metal bushings furnished in grinding wheels should not extend beyond the sides of the wheel.

5. Normally, grinding wheels come equipped with washers or flange facings of compressible material between the faces of the wheel and its flanges. If these washers are not on the wheel, they must be applied before the wheel is mounted.

6. Spindle nuts should be tightened just enough to hold the wheel firmly; otherwise, the clamping strain is likely to damage the wheel or its associated parts.

7. All surfaces of grinding wheels, washers, and flanges in contact with each other, should be clean and free from foreign matter.

Operation of Grinding Wheels

1. Grinding wheels must not be operated at speeds greater than those recommended by the wheel manufacturer. This speed is usually stamped on the side of the wheel.

2. A new grinding wheel should be revolved for about 1 min before being applied to the work; the operator should stand aside while the wheel is being tested.

3. A cold wheel should not be forced against the work. It should be applied gradually and given a chance to warm up. This will lessen the danger of heat shock developing cracks in the wheel.

4. A grinding wheel should not be forced beyond its capacity by applying excess pressure.

5. Grinding-wheel guards must be kept in place and in good condition.

6. The engine should never be started while a grinding wheel is in contact with any surface.

Protection Hood or Guard

1. Every grinding machine or portable hand grinder must be provided with an approved protection hood or guard.

2. Grinding machines or portable hand grinders must not be operated without the protection hood or guard securely fastened in place.

3. Work rests, if used, shall be kept adjusted to the wheel with a maximum distance of ⅛ in to prevent the work from being caught between the wheel and the rest. The work rest should be securely clamped after each adjustment. The adjustment must not be made while the wheel is in motion.

Report on Assignment 11

System vs Division Shop for Maintaining Work Equipment

L. B. Waterman (chairman, subcommittee), R. W. Bailey, O. C. Benson, R. E. Buss, J. W. Cummings, J. O. Elliott, M. E. Kerns, E. L. Mire, F. E. Short, R. J. Smith, H. A. Thyng, F. E. Yockey.

This is a final report, submitted as information.

Because of the increased number of units of mechanized work equipment in service and the complexities that arise from their use, each individual railroad should make a study to determine the best methods to properly and economically maintain its various units. Only when this equipment is properly maintained will the railroads receive an adequate return on their large equipment investment.

Reference is made to several studies reported in previous Proceedings as follows: Vol. 47, pages 182 to 185, and Vol. 32, pages 475 to 481, these two reports concerning supervisor organization and practices in maintaining work equipment; and Vol. 60, pages 461 to 468, Vol. 51, pages 278 to 282, and Vol. 47, pages 185 to 192, all concerned with recommendations for machinery and tools needed for repairs to work equipment, both for shop and field forces.

One of the main problems to be considered is the type of shop system necessary for the best performance of all repair work beyond the capacity of the field repairmen. Various types of shops exist, some being called division, district, regional and system shops. Their name and duties differ among the various roads. Division and district shops are basically similar in that they are equipped to perform light repairs to small and medium-size machines, make repairs to automotive equipment, and have little special machinery. These shops are called division shops in this report.

On some roads regional shops have duties that correspond to the system shops on other roads. In these shops heavy repairs and overhauls to all machines are made where specialized machinery as well as skilled personnel are needed. In this report, this type of shop will be discussed under the heading System Shops. The recommended work for each is outlined, together with some of their advantages and disadvantages.

Some roads may prefer to have many smaller shops on the division level rather than one or several larger shops on a system level, or vice versa, or some may decide that both types are needed to maintain and overhaul their equipment. All shops, regardless of their size, must be properly equipped to handle all the work assigned to them

and must have qualified personnel. It is preferable that all shops come under the jurisdiction of the maintenance of way or engineering departments for closer coordination with the field forces using the equipment, better programming in utilizing the equipment, and better control of over-all maintenance costs.

The physical size of the railroad will have much to do with the type of shop system that is set up. A large railroad, spread over several thousands of miles could, no doubt, use to good advantage both system and division shops. A smaller railroad, with a mileage under 1,000, might desire one system shop to perform all of its heavy maintenance work. The length of time and distances involved in getting units to a shop should be considered in choosing shop location and type, particularly if it is not centrally located. Other considerations for determining shop sizes would be the actual number of pieces of work equipment, this having a bearing on the potential of the work to be done; the length of the working season, this reflecting the number of units to be worked on at one time; shop personnel, their efficiency and knowledge to repair the types of units sent to that shop; the amount of repair parts that should be stocked; and the availability of replacement parts and dealer services.

System Shop

In a system shop all major equipment and automotive vehicle overhauls, modifications and developments should be performed. This is the ideal place for repowering cranes, modernizing, or making major repairs to, surfacing machines, ballast regulators, tie machines, ballast cleaners, bulldozers, shovels and other large machines. This shop would work on the development of new equipment and make all necessary preliminary tests. Facilities should be provided for rebuilding and testing diesel and gasoline engines, hydraulic pumps, motors and other appurtenances, and for stocking major component parts for all units operating on the system. Both new and rebuilt parts could be shipped direct from this shop to the smaller field shops either to replenish the supply at these points or for direct application to field units.

This large shop would be the best place to perform complete overhauling of all units of a particular make. This would permit a diversified division of work, resulting in a lower labor cost per unit. The over-all quality of repair work could be better controlled through better inspection and closer supervision.

Shops of this type should work closely with manufacturers' servicemen and repair facilities. Any suggested changes on equipment would first be checked with the manufacturer. If these are found satisfactory under the road's operating conditions, necessary instructions could be given to the division shops or repairmen for making the modifications in the field. Advantage should be taken of certain repair facilities of the manufacturers or their distributors so that expensive tools that are only occasionally used could be borrowed or rented rather than bought. By working closely with the manufacturers and their representatives, the shop could keep a closer control on the purchasing and pricing of spare and repair parts, and could hold to a minimum the number of obsolete items.

Division Shops

This form of shop has for its main function light repairs to equipment. Field mechanics can work directly with this shop or possibly use it as a headquarters. It could be used for light repairs to field units and the making of engine replacements, or it could make any minor modifications to machines that could not be easily handled in the field. The shop would be close enough to large mechanized field gangs to help keep the downtime of any of their units to a minimum. It would stock small rebuilt engines,

tamping bars, various hydraulic pumps and motors, belts of all types, batteries, wheels, axles, filters, plugs, and the like. The field mechanics would replenish their individual stock or draw directly on this shop for supplies. Some form of truck arrangement should be provided at this location so that disabled units could be quickly brought in for repairs. Its main job would be to reduce the work load of the system shop. Therefore, it should be provided with the proper facilities for making light repairs and modifications to all light and medium work equipment and for handling the maintenance of automotive vehicles.

System Shops—Advantages and Disadvantages

The chief advantage of this type of shop is that it can be equipped with specialized tools and machines that it would be unprofitable to supply to all division shops. Here all heavy work could be concentrated, and skilled mechanics would have more opportunity to work on similar machines. This results in better efficiency in work and lowers the labor cost per unit. A closer control of spare parts could be maintained for use in the shop and line-of-road, thus avoiding unnecessary duplication of high inventories. Salvage and reclamation of equipment parts are more logical at this point because skilled personnel and special testing equipment are available.

One of the disadvantages of this type of shop is the time lost because of the long distances that equipment must be shipped when sent in for repairs. Often this shop cannot be located at a central point to hold the shipping time to the minimum. Also, because of delays in transit, it is sometimes difficult for a shop to properly schedule the actual shop time of a unit.

Division Shops—Advantages and Disadvantages

The chief advantage of a division shop is its closer proximity to the operating field units, minimizing the time lost in sending machines in for repairs. These repairs would be those that the repairman could not perform in the field. Shops of this size could aid a system shop in being able to reduce the work load at the larger shop.

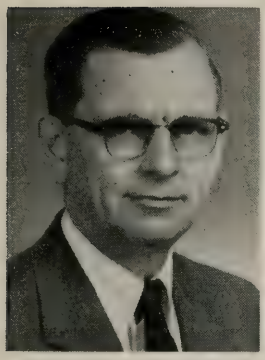
The disadvantages of this form of shop are related to personnel, shop equipment, and the fact that it generally requires a larger shop to supplement its work. Personnel can not become thoroughly familiar with all types of machines, as some units are in a territory for only short periods of time. Expensive machinery and tools are not justified at this type of shop because of limited manpower, and the fewer numbers and varieties of machines that can be worked on. This form of shop system requires a larger railroad ownership of equipment because more equipment would be tied up in the various division shops. A larger shop would still be necessary to adequately perform the heavy specialized repair and overhaul work.

Conclusions

The committee feels that each road must decide, before any choice of shop system is set up, just how much repair work must be done, and where it can be done to the best advantage. The physical size and characteristics of each will help determine whether system or division or both types of shop systems are necessary. The number of individual working units and the length of the working season would determine the size of the shops needed. All existing shops, regardless of type or size, should be brought up to date so that each could perform the work that would normally be assigned to it.

The proper maintenance of all automotive vehicles and work equipment must be done as economically and efficiently as possible to keep the various units at their best rates of performance for the maximum length of time. This will result in longer life and a better return on the equipment dollar.

Report of Committee 28—Clearances



S. M. Dahl, *Chairman,*
J. G. Greenlee,
Vice Chairman,

C. O. Bird
E. S. Birkenwald
B. Bristow
D. H. Brown
W. T. Davis
J. E. Fanning (E)
J. E. Good
A. R. Harris
W. F. Hart
C. F. Intlekofer
W. P. Kobat
W. H. Martin
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E. E. Mills
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R. C. Nissen
C. E. Peterson
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J. F. Smith
J. W. Wagner
J. W. Wallenius
A. M. Weston
H. G. Whittet, Jr.
R. L. Williams
M. A. Wohlschlaeger
Committee

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No revisions are proposed this year under this assignment, but Manual recommendations are presented under Assignments 2, 3 and 5.

2. Clearances as affected by girders projecting above top of track rails, structures, third rail, signal and train control equipment, collaborating with Signal and Electrical Sections, and with Mechanical and Operating–Transportation Divisions, AAR.

   Two clearance diagrams submitted for adoption and publication in the Manual ..... page 542

3. Review clearance diagrams for recommended practice, collaborating with AREA committees concerned, and the AAR Joint Committee on Clearances.

   Four clearance diagrams submitted for reapproval without change, and four clearance diagrams submitted for reapproval with revisions ..... page 545

4. Compilation of the railroad clearance requirements of the various states.

   No report. A completely new and revised tabulation of clearance requirement of the various states is being prepared and will be ready for publication a year hence.

5. Clearance allowances to provide for vertical and horizontal movements of equipment, due to lateral play, wear and spring deflection, collaborating with the Mechanical Division, AAR.

   Progress report, including a method of determining clearance allowances for passenger equipment, submitted for adoption and publication in the Manual . page 549

6. Compilation in table form of offsets for overhanging loads on curves.

   No report for publication this year. The tabulation of offsets is nearing completion and will be ready in 1961.

7. Methods of measuring high and wide shipments.

   Progress report, with drawing of suggested measuring devices, presented as information with the view of presenting it for adoption and publication in the Manual a year hence ..... page 555

THE COMMITTEE ON CLEARANCES,
S. M. DAHL, *Chairman.*

AREA Bulletin 554, December 1959.

Report on Assignment 2

Clearances as Affected by Girders Projecting Above Top of Track Rails, Structures, Third-Rail, Signal and Train Control Equipment

Collaborating with Signal and Electrical Sections and with Mechanical and Operating Transportation Divisions, AAR

J. G. Greenlee (chairman, subcommittee), C. O. Bird, E. S. Birkenwald, D. H. Brown, S. M. Dahl, W. T. Davis, J. E. Good, A. R. Harris, W. F. Hart, W. H. Martin, A. G. Neighbour, C. E. Peterson, W. S. Ray, J. W. Wagner, A. M. Weston, H. G. Whittet, R. L. Williams.

Your committee submits for adoption and inclusion in the AREA Manual, a diagram of Clearance Lines for Third-Rail Territory. This diagram (presented on page 543) has been developed through collaboration with the Railway Electrification Committee of the AAR Electrical Section, and is identical to the diagram which appears in the Electrical Section Manual.

Your committee also submits for publication in the Manual, as information, Equipment Diagram Unrestricted for Interchange Service (presented on page 544), to replace the following two equipment diagrams in the Manual.

Page 28–3–1

EQUIPMENT DIAGRAM UNRESTRICTED (Fig. 1)

Page 28–3–2

EQUIPMENT DIAGRAM UNRESTRICTED FOR MAIN LINES (Fig. 2)

The new diagram is identical to the Equipment Diagram—Unrestricted for Interchange Service, of the Mechanical Division, AAR, known as Plate "B," and referred to in Car Service Rule 14 (e) as the maximum dimensions for cars in interchange service.

CLEARANCE LINES FOR THIRD-RAIL TERRITORY*

NOTE 1 - THE THIRD RAIL HAS TWO LOCATIONS, ONE LOCATION AS SHOWN WITH SOLID LINES FOR TANGENTS AND CURVES NOT EXCEEDING 7°-10'. THE SECOND LOCATION FOR SWITCHES AND CURVES EXCEEDING 7° -10', SHOWN IN DASH LINES.

NO PART OF THE THIRD-RAIL STRUCTURE OR TRAIN CONTROL IN THIRD-RAIL TERRITORY SHALL PROJECT BEYOND THE THIRD-RAIL CLEARANCE LINES HT-GT-FT-AT-BT-CT-DT-ET-JT-KT-LT, EXCEPT ON SWITCHES AND CURVES EXCEEDING 7°-10', USE THE DASH CLEARANCE LINES H'T'-G'T'-F'T'-A'T'-B'T'-C'T'.

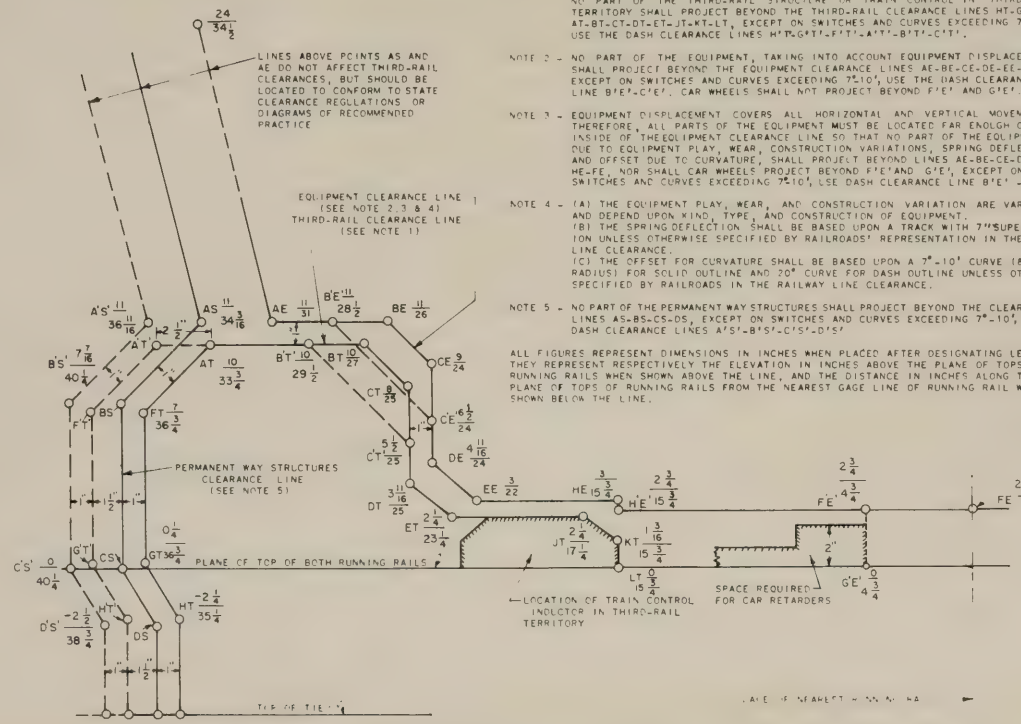
NOTE 2 - NO PART OF THE EQUIPMENT, TAKING INTO ACCOUNT EQUIPMENT DISPLACEMENT, SHALL PROJECT BEYOND THE EQUIPMENT CLEARANCE LINES AE-BE-CE-DE-EE-HE-FE, EXCEPT ON SWITCHES AND CURVES EXCEEDING 7°-10', USE THE DASH CLEARANCE LINE B'E'-C'E'. CAR WHEELS SHALL NOT PROJECT BEYOND F'E' AND G'E'.

NOTE 3 - EQUIPMENT DISPLACEMENT COVERS ALL HORIZONTAL AND VERTICAL MOVEMENT THEREFORE, ALL PARTS OF THE EQUIPMENT MUST BE LOCATED FAR ENOUGH ON THE INSIDE OF THE EQUIPMENT CLEARANCE LINE SO THAT NO PART OF THE EQUIPMENT, DUE TO EQUIPMENT PLAY, WEAR, CONSTRUCTION VARIATIONS, SPRING DEFLECTION, AND OFFSET DUE TO CURVATURE, SHALL PROJECT BEYOND LINES AE-BE-CE-DE-EE-HE-FE, NOR SHALL CAR WHEELS PROJECT BEYOND F'E' AND G'E', EXCEPT ON SWITCHES AND CURVES EXCEEDING 7°-10', USE DASH CLEARANCE LINE B'E' - C'E'

NOTE 4 - (A) THE EQUIPMENT PLAY, WEAR, AND CONSTRUCTION VARIATION ARE VARIABLE AND DEPEND UPON KIND, TYPE, AND CONSTRUCTION OF EQUIPMENT.
(B) THE SPRING DEFLECTION SHALL BE BASED UPON A TRACK WITH 7" SUPERELEVATION UNLESS OTHERWISE SPECIFIED BY RAILROADS' REPRESENTATION IN THE RAILWAY LINE CLEARANCE.
(C) THE OFFSET FOR CURVATURE SHALL BE BASED UPON A 7°-10' CURVE (800' RADIUS) FOR SOLID OUTLINE AND 20° CURVE FOR DASH OUTLINE UNLESS OTHERWISE SPECIFIED BY RAILROADS IN THE RAILWAY LINE CLEARANCE.

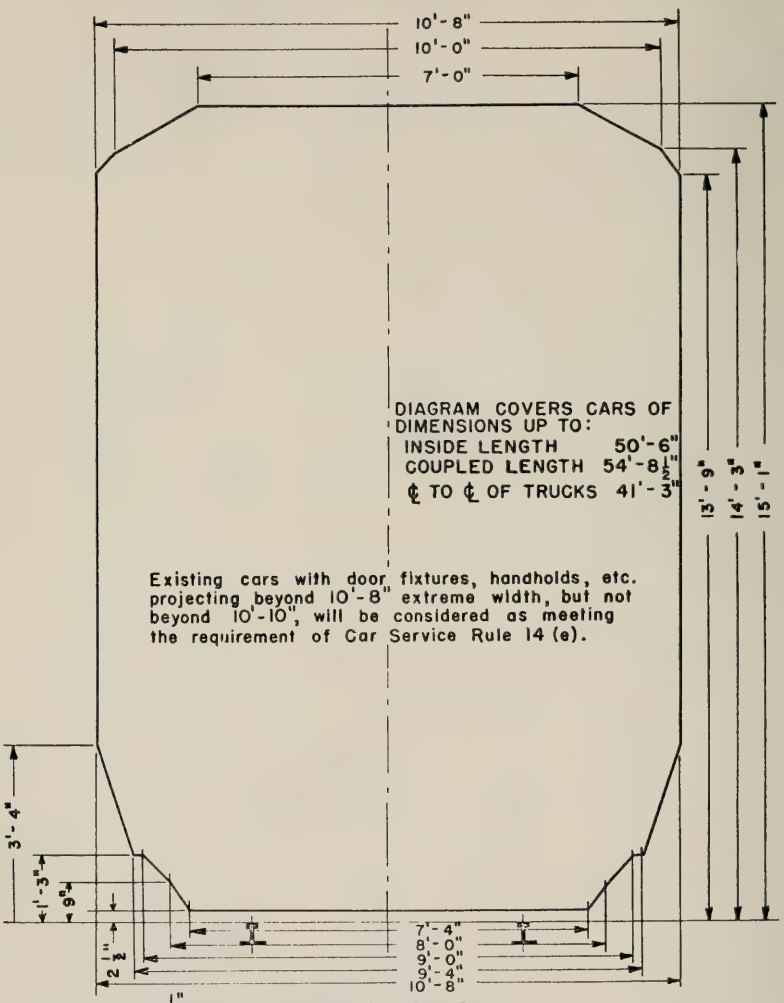
NOTE 5 - NO PART OF THE PERMANENT WAY STRUCTURES SHALL PROJECT BEYOND THE CLEARANCE LINES AS-BS-CS-DS, EXCEPT ON SWITCHES AND CURVES EXCEEDING 7°-10', USE DASH CLEARANCE LINES A'S'-B'S'-C'S'-D'S'

ALL FIGURES REPRESENT DIMENSIONS IN INCHES WHEN PLACED AFTER DESIGNATING LETTERS. THEY REPRESENT RESPECTIVELY THE ELEVATION IN INCHES ABOVE THE PLANE OF TOPS OF RUNNING RAILS WHEN SHOWN ABOVE THE LINE, AND THE DISTANCE IN INCHES ALONG THE PLANE OF TOPS OF RUNNING RAILS FROM THE NEAREST GAGE LINE OF RUNNING RAIL WHEN SHOWN BELOW THE LINE.



* This diagram is identical to the diagram that appears in the Manual of the Electrical Section, AAR.

EQUIPMENT DIAGRAM UNRESTRICTED FOR INTERCHANGE SERVICE*



THE 2½" ABOVE TOP OF RAIL IS ABSOLUTE MINIMUM UNDER ANY AND ALL CONDITIONS OF LADING, OPERATION, AND MAINTENANCE.

All new or rebuilt cars should be so designed that no part of car shall be less than 2-3/4 in. above the top of the running rail under all allowable wear and spring deflection conditions. Those roads using multiple wear wheels may find it necessary, in maintaining the 2-3/4 in. minimum clearance, to compensate for wheels worn close to the condemning limit by replacing wheel and axle sets, bearings or wedges.

* This diagram is the same as Plate B of the Mechanical Division, AAR, and is included in the AREA Manual for convenient reference.

Report on Assignment 3

Review Clearance Diagrams for Recommended Practice

Collaborating with AREA Committees Concerned and the AAR Joint Committee on Clearances

R. L. Williams (chairman, subcommittee), E. S. Birkenwald, B. Bristow, S. M. Dahl, W. T. Davis, J. E. Fanning, J. E. Good, J. G. Greenlee, A. R. Harris, W. P. Kobat, J. W. McMillen, R. C. Nissen, R. A. Skooglun, J. W. Wagner, J. W. Wallenius, A. M. Weston.

Your committee submits the following recommendations with respect to clearance diagrams appearing in Chapter 28 of the Manual:

Page 28–2–1

CLEARANCE DIAGRAM FOR RAILWAY BRIDGES (Fig. 1)

Reapprove without change.

Page 28–2–2

CLEARANCE DIAGRAM FOR TURNTABLES (Fig. 2)

Reapprove without change.

Page 28–2–3

CLEARANCE DIAGRAM FOR SINGLE-TRACK TUNNEL (Fig. 3)

Reapprove without change.

Page 28–2–4

CLEARANCE DIAGRAM FOR DOUBLE-TRACK TUNNEL (Fig. 4)

Reapprove without change.

Page 28–2–5

CLEARANCE DIAGRAM FOR BUILDINGS AND SHEDS ADJACENT TO SIDE TRACKS (Fig. 5)

Reapprove with the following revisions:

Change title to read: "Clearance Diagram for Structures (Other than Platforms) Adjacent to Industrial Side Tracks."

Change drawing to show that no special encroachment for sheds is permitted other than in the 4 by 6-ft triangles in the upper corners. (Revised diagram presented herewith.)

CLEARANCE DIAGRAM FOR STRUCTURES (OTHER THAN PLATFORMS) ADJACENT TO INDUSTRIAL SIDE TRACKS

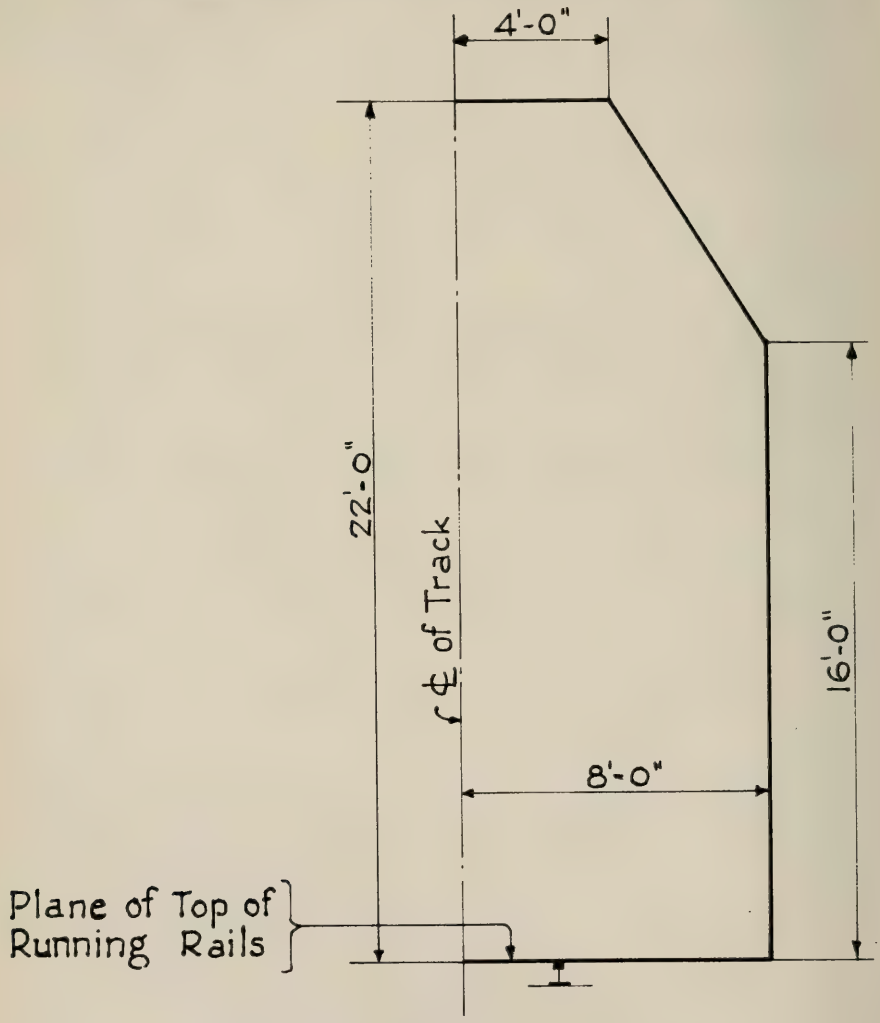


Fig. 5.

Page 28-2-6

CLEARANCE DIAGRAMS FOR WAREHOUSE AND ENGINEHOUSE DOORS (Fig. 6)

Reapprove with the following revisions:

Change title to read: "Clearance Diagram for Building Doors."

Increase height from 17 to 18 ft and the half-width for building doors from 7 to 8 ft. (Revised diagram presented herewith.)

CLEARANCE DIAGRAM FOR BUILDING DOORS

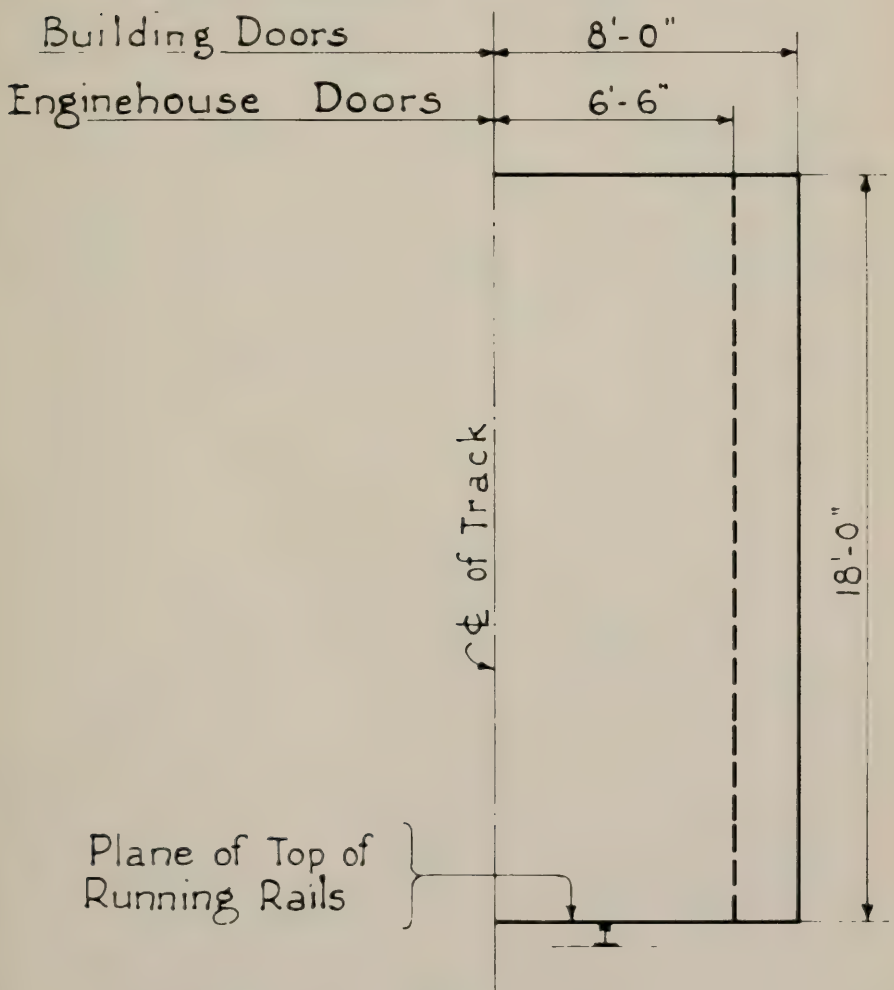


Fig. 6.

Page 28–2–7

CLEARANCE DIAGRAMS FOR PLATFORMS (Figs. 7 and 8)

Reapprove with the following revisions:

Revise Fig. 7 to provide 8 ft from center line of track to high platform unless clearance on the other side conforms to Fig. 5. Increase maximum height of low platform to 8 in and limit maximum height of high platform to 4 ft. Revise Fig. 8 to limit height of platform to 4 ft. (Revised diagrams presented herewith).

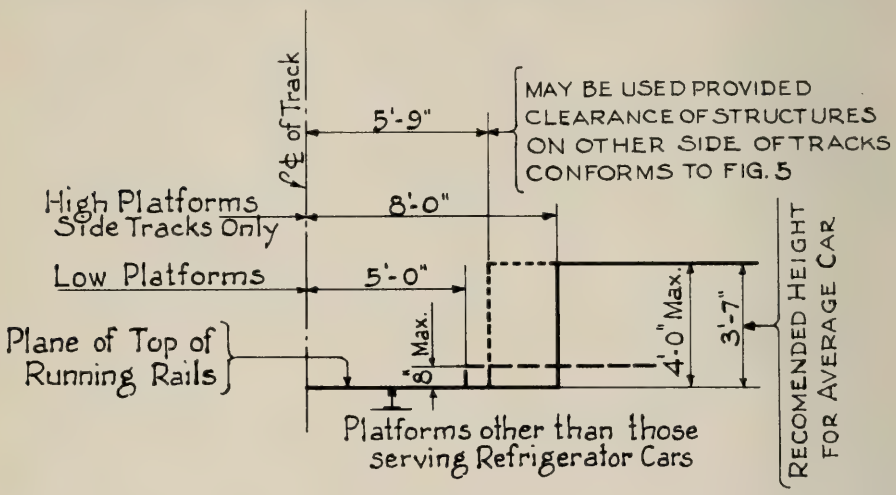


Fig. 7.

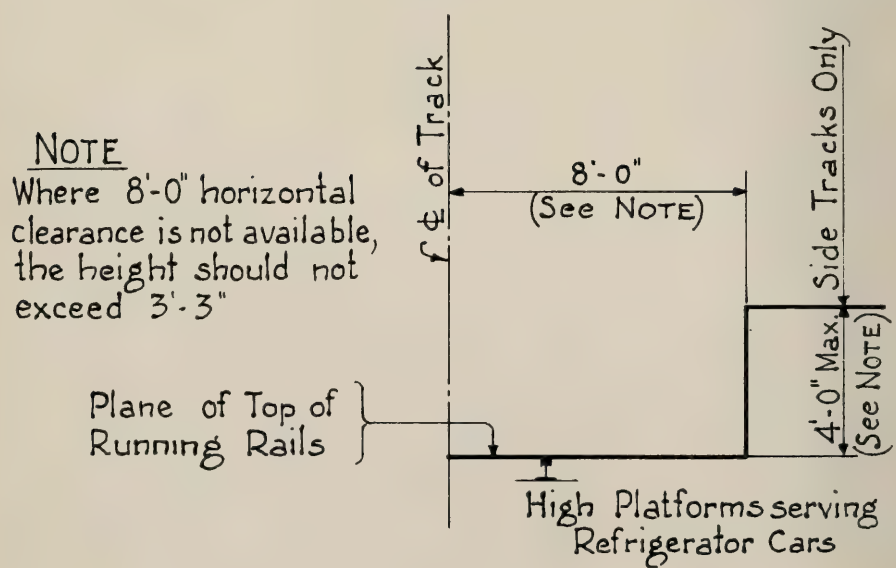


Fig. 8.

These revisions will bring AREA clearance requirements more in line with the requirements of the majority of the various states. As a result of collaboration with the AAR Joint Committee on Clearances, no change in the basic horizontal clearance of 8 ft is recommended. All of the above diagrams, therefore, retain this basic clearance.

Collaboration is still in progress on a new diagram, Fig. 9—Clearance for Overhead Bridges and Other Structures Not Otherwise Provided For.

Report on Assignment 5

Clearance Allowances to Provide for Vertical and Horizontal Movements of Equipment Due to Lateral Play, Wear and Spring Deflection

Collaborating with the Mechanical Division, AAR

E. E. Mills (chairman, subcommittee), C. O. Bird, B. Bristow, D. H. Brown, S. M. Dahl, W. T. Davis, J. G. Greenlee, A. R. Harris, C. F. Intlekofer, J. R. Moore, C. E. Peterson, W. S. Ray, J. F. Smith, R. L. Williams, M. A. Wohlschlaeger.

Your committee submits herewith, for approval as recommended practice and publication in the Manual, a method of determining clearance allowances for horizontal movement of passenger cars. This method was presented last year as information. (Proceedings, Vol. 60, 1959, page 1109).

The method has been developed and tested through field tests on passenger cars carried out by the AAR under the direction of G. M. Magee, director of engineering research. A report on these tests entitled "Passenger Ride Comfort on Curved Track" will be found in the Proceedings, Vol. 56, 1955, page 125. Other background material will be found in the reports of committee 28 in the Proceedings, Vol. 56, 1955, page 559, and Vol. 59, 1958, page 661.

Further tests on freight equipment have been run on the Lackawanna Railroad to supplement the full-load tests run on the same railroad earlier. The results of these tests will be the subject of a future report.

CLEARANCE ALLOWANCES FOR HORIZONTAL MOVEMENTS OF PASSENGER CARS DUE TO LATERAL PLAY, WEAR AND SPRING DEFLECTION

The calculation of lateral clearance requirements for passenger cars on curved track involves the following factors:

1. Width of cars.
2. Overhang at ends and middle of cars due to curvature.
3. Elevation of outer rail.
4. Lateral play between wheels and rails.
5. Roll of car body, due to unequal spring deflections and play in side bearings.
6. Displacement due to swing-hanger movements and lateral play and wear in truck parts.
7. Allowances for the effect of track irregularities and dynamic behavior of equipment.

The first four factors can easily be calculated and present no problem. A method of determining allowances for factors 5, 6 and 7 is presented below.

The roll of the car body, with respect to the truck, on curved track occurs when the effect of the centrifugal force is not exactly balanced by the elevation in the track. When this condition exists, there is an "unbalanced elevation" equal to the deficiency or excess of elevation required for equilibrium. Such unbalanced elevation has a similar effect on a moving car as elevated track has on a standing car for equal values of unbalanced elevation and track elevation.

The determination of the lateral displacement of the car body due to swing-hanger movements and lateral play and wear in the truck parts, may, for all practical purposes, be combined with the lateral displacement due to tilting, and the two factors may be determined, as follows:

1. Make static tests on elevated track, preferably at 2 in, 4 in and 6 in elevation.
2. Make measurements as shown in Fig. 1 to determine value of L.
3. Plat L values, as in Fig 3, and draw line through the zero of coordinates and of average of L values and extend line into area of positive values of unbalanced elevation and displacement.

The lateral displacement of a moving car with reference to the center line of car trucks may now be determined, as follows:

4. Calculate unbalanced elevation from formula

$$E_u = E_r - E_a$$

where

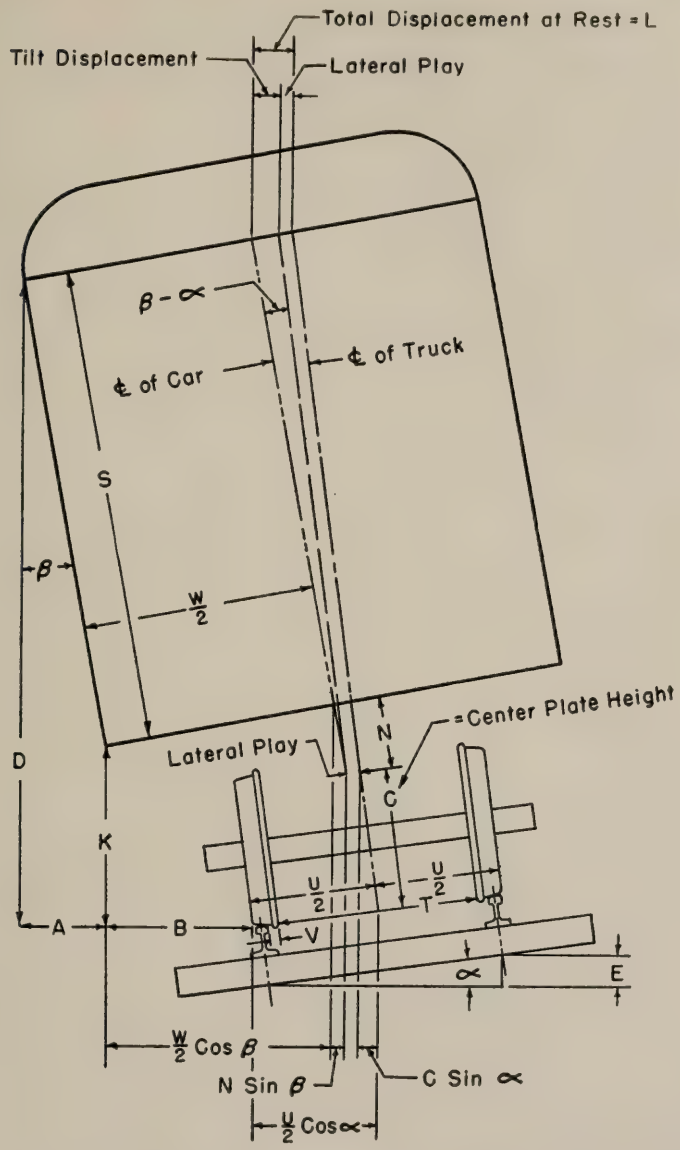
E_u = Unbalanced elevation
E_r = Elevation required for equilibrium
E_a = Actual elevation in the track

5. Determine average lateral displacement R (Fig. 2) corresponding to the unbalanced elevation, determined in step 4 from chart drawn under step 3.

The value of R may be either plus or minus, depending upon whether the speed of the car is more or less than the speed required for equilibrium.

The results obtained are only as good as the basic information, such as degree of curvature and elevation. For best results, it is recommended that actual field conditions be determined by actual field measurement, determining curvature by string lining and elevation by cross levels. Variation of a few minutes in curvature should not be ignored.

Since track and equipment conditions are variable, to some extent, allowance must be added to the calculated average displacement to provide for track irregularities and the dynamic behavior of equipment. This allowance cannot be determined exactly. Recommended allowances, expressed as a percentage of the average displacement, for various speeds, are shown in Fig. 4 and are based upon field tests on high-speed track of eight passenger cars having various types of trucks. This allowance is to be added to the displacement as calculated above.



$$L = (S+N)\sin(\beta-\alpha) + (B + \tfrac{U}{2}\cos\alpha) - (\tfrac{W}{2}\cos\beta + N\sin\beta + C\sin\alpha)$$

FIG. 1 DIAGRAM SHOWING STATIC TEST MEASUREMENTS REQUIRED FOR CALCULATION OF "L"

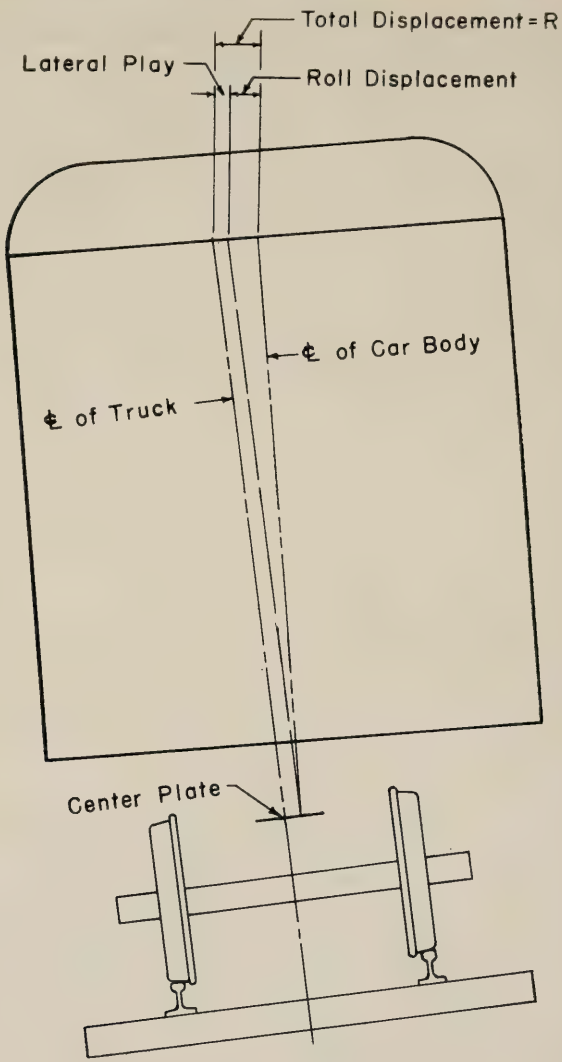


FIG. 2 DIAGRAM SHOWING DISPLACEMENT "R" OF A CAR MOVING ON A CURVE IN EXCESS OF EQUILIBRIUM SPEED

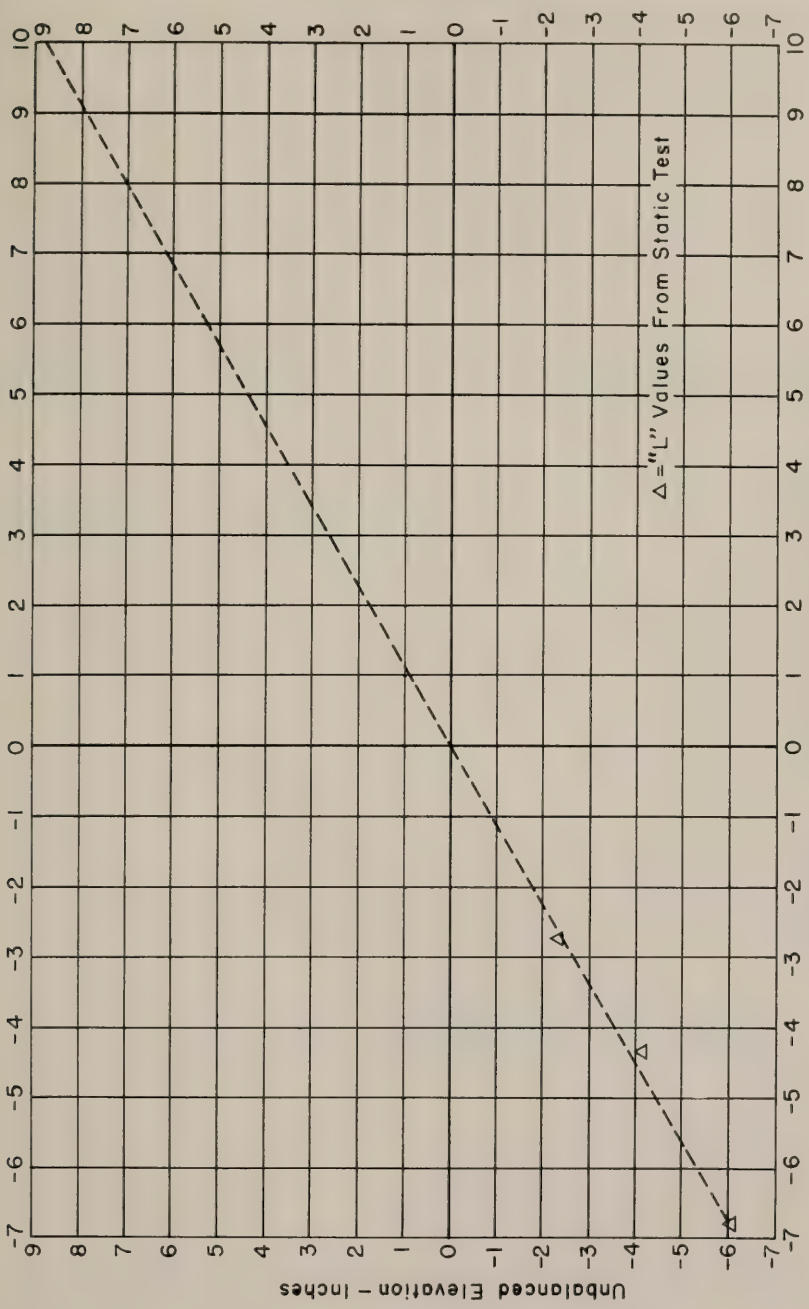


FIG. 3 DIAGRAM SHOWING RELATION BETWEEN DISPLACEMENT AND UNBALANCED ELEVATION

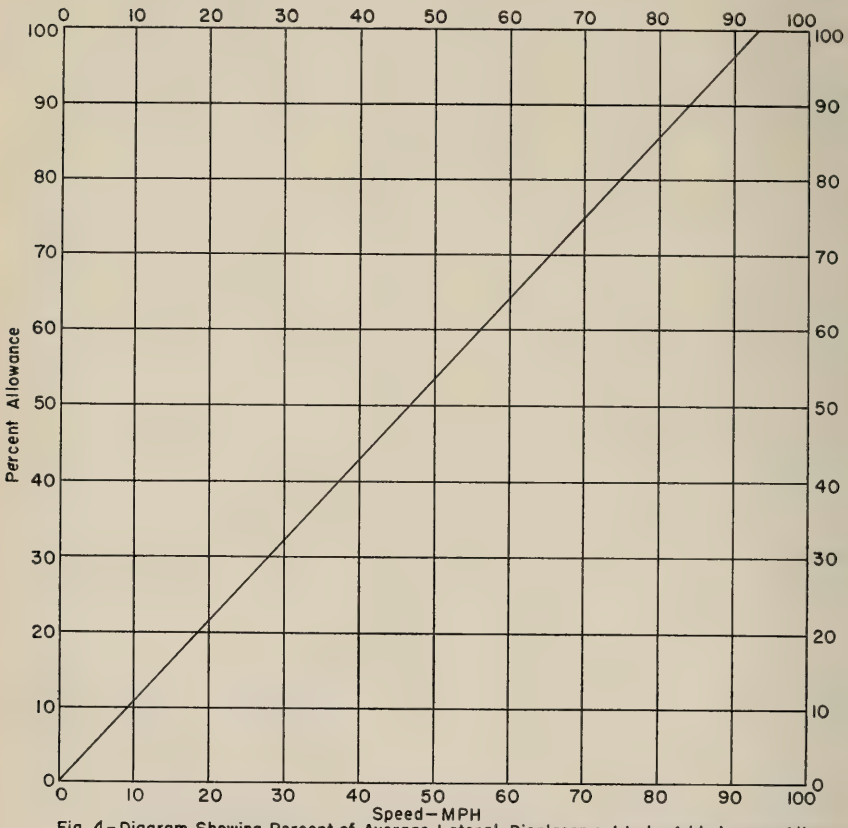


Fig. 4—Diagram Showing Percent of Average Lateral Displacement to be Added, as an Allowance for the Effect of Track Irregularities and Dynamic Behavior of Passenger Cars.

Report on Assignment 7

Methods of Measuring High and Wide Shipments

R. A. Skooglun (chairman, subcommittee), C. O. Bird, D. H. Brown, S. M. Dahl, W. F. Hart, W. P. Kobat, W. H. Martin, J. W. McMillen, E. E. Mills, C. E. Peterson, J. F. Smith, J. W. Wallenius, H. G. Whittet, Jr., J. W. Wagner.

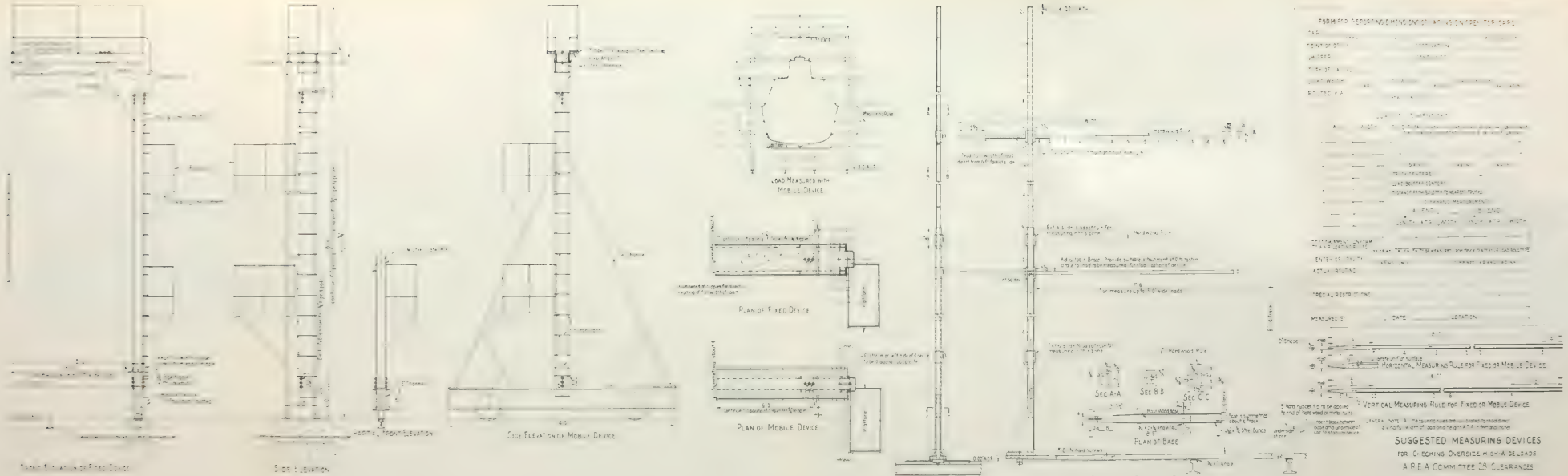
Your committee submits as information, with the view of submitting it as Manual material after collaboration with the Mechanical Division, AAR, the accompanying drawing entitled "Suggested Measuring Devices for Checking Oversize High-Wide Loads" which, in brief, includes:

1. A fixed device for the measurement of high-wide loads that can be placed in a permanent position, either within or without a protecting structure. Cars to be checked are switched into position at the measuring device. Calibrated horizontal and vertical measuring rods, shown on plan, are then inserted into the holes at the side and top of the device, furnishing direct readings as to the width and height of load without the necessity of adding or subtracting any constant.

2. A mobile device for the measurement of high-wide loads that can be placed in a permanent position on appropriate running rails either within or without a protecting structure. Cars to be checked do not require switching, and width and height of loads are then obtained similar to the fixed device.

3. A portable device that can be set up at any location in a yard or wherever cars are located that require measurements. Measurements are made with calibrated rods similar to fixed device.

4. A form for reporting of lading on open-top cars, which is self-explanatory.


Side Elevation
Side Elevation of Mobile Device
Load Measured with Mobile Device
Plan of Fixed Device
Plan of Mobile Device
Side Elevation
Front Elevation of Portable Device
Sec A-A
Sec B-B
Sec C-C
Plan of Base
Vertical Measuring Rule for Fixed or Mobile Device
Suggested Measuring Devices
for Checking Oversize Highway Loads
A.R.E.A. Committee 28 Clearances

Report of Committee 15—Iron and Steel Structures

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James Michalos
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N. M. Newmark
J. C. Nichols
T. G. O'Neil
R. E. Peck
G. H. Perkins
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C. A. Roberts
G. E. Robinson
G. W. Salmon
C. H. Sandberg
T. C. Shedd*
A. E. Smith
H. F. Smith
J. E. South
G. L. Staley
H. C. Tammen (E)
W. M. Thatcher
E. K. Timby
L. E. Titlow
H. T. Welty (E)
A. R. Wilson (E)
L. T. Wyly
Committee

(E) Member Emeritus.
* Died July 11, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Revision of Specifications for Steel Railway Bridges, submitted for adoption and publication in the Manual ..... page 560

   Reapproval without change of Manual Material, submitted for adoption and publication in the Manual ..... page 561

   Revision of Specifications for Steel Railway Bridges, submitted as information ..... page 561

   Revision of Specifications for Movable Railway Bridges, submitted as information ..... page 563

2. Design of composite steel and concrete spans, collaborating with Committees 8 and 30.

   Specifications are in preparation. Tests being made at Lehigh University, New York University, and elsewhere, may lead to substantial economies on the shear connectors required.

3. Corrosion of deck plates.

   Progress report, presented as information ..... page 580

4. Stress distribution in bridge frames.

   (a) Floorbeam hangers.

   Progress report, presented as information ..... page 581

   (c) Truss bridge research project.

   Progress report, presented as information ..... page 582

5. Design of steel bridge details.

   Revision of specifications to permit more economy in splicing of girder webs is being studied. Possible simplifications of rules for applying net-section rules to net moment of inertia computations are being considered.

6. Preparation and painting of steel surfaces.

   Progress report, presented as information ..... page 583

7. Bibliography and technical explanation of various requirements in AREA specifications relating to iron and steel structures.

   Work on this subject is being expanded to include specification parts not included in last year's progress report. The review of specifications made in connection with this assignment has disclosed some inconsistencies, which will be clarified. The committee expects to recommend at the March 1961 convention that last year's progress report, with a few revisions, be adopted as Manual material.

8. Specifications for the design of corrugated metal culverts, including corrugated metal arches. Some questions have been raised concerning the proposed specifications published in last year's progress report. However, the committee believes that these have been satisfactorily resolved, and recommendations will be made next year that these specifications be adopted as Manual material.

9. Synthetic resins and other adhesive materials for protective coating and reinforcement.

   These materials have found extensive use in timber and in specialized metal construction, such as in airplanes, but in ordinary steel construction their use is still experimental. However, a German steel bridge, 186 ft long, carrying a pipeline and pedestrian traffic, was built about 3 years ago with members connected by a resin-type adhesive.

THE COMMITTEE ON IRON AND STEEL STRUCTURES,
D. V. MESSMAN, *Chairman.*

AREA Bulletin 555, January 1960.

MEMOIR

Thomas Clark Shedd

Thomas Clark Shedd, a member of Committee 15 since 1936, and professor of structural engineering, emeritus, in the Department of Civil Engineering of the University of Illinois, died on July 11, 1959, at Urbana, Ill. He was born on July 2, 1890, in Worcester, Mass. and attended the University of Virginia and Brown University, from the latter of which he was graduated in 1913 with the degree of Bachelor of Science in Mechanical Engineering. He received the degrees of Civil Engineer in 1925 and Master of Science in 1933 from the University of Illinois.

Professor Shedd started his career by teaching for two years at Brown University immediately after his graduation. After six years of employment with the Phoenix Bridge Company, he returned to teaching at Lehigh University. His affiliation with the University of Illinois began in 1922. He held the position of professor of structural engineering from 1934 to the time of his retirement in 1958.

He was a member of many professional organizations. He joined the American Railway Engineering Association in 1935. He was a member also of the American Society for Engineering Education, the American Concrete Institute, the International Association for Bridge and Structural Engineering, the Illinois Society of Professional Engineers, and the American Society of Civil Engineers in which he served from 1953 to 1956 as National Director from District VIII.

Professor Shedd was a member of the Illinois Structural Engineers' Examining Committee from 1944 to 1959 and served as chairman for several terms. He was a member of the Illinois Professional Engineers' Examining Committee from 1945 to 1959 and was chairman from 1945 to 1948. He also served as president and director of the National Council of State Boards of Engineering Examiners.

An outstanding and devoted teacher, Professor Shedd dedicated much of his life to education and to his students. His success in teaching was based on clear and simple exposition of subject matter, with a special emphasis on the fundamentals. Through his lectures and assignments, which were related to actual projects, he developed the imagination of his students while arousing their interest and enthusiasm. His two outstanding textbooks contributed immensely to the understanding of fundamentals of analysis and design. His first book, "Theory of Simple Structures", was written jointly with the late Professor Jamison Vawter, a member for many years of Committee 8 and Professor of Civil Engineering, Emeritus, at the University of Illinois. His second book, "Structural Design in Steel", set a new standard in clarity of presentation and breadth of coverage. It has been used extensively not only in the classroom but by practicing engineers.

His former students include many of the country's outstanding engineers, for whom the inspiration received in his classes is a lasting memory. He was a constant source of encouragement to his colleagues, and when called upon for advice or assistance he always responded eagerly and cheerfully. He served on many important assignments for Committee 15, and gave freely of his time and energy in his service to AREA.

No one can remember Thomas Shedd without a feeling of deep respect for his principles and appreciation of his dedication to his life's work.

N. M. Newmark,
J. G. Clark,
W. H. Munse,
Committee on Memoir.

MEMOIR

Lacy Lambert Shirey

Lacy Lambert Shirey, retired bridge engineer of the Chesapeake & Ohio Railway, died on March 15, 1959, at Richmond, Va.

Mr. Shirey was born on May 23, 1891, at Union, W. Va. His early education was obtained at local schools. After graduating from Dunsmore Business College, Staunton, Va., he attended Washington and Lee University at Lexington, Va., receiving a B.S. degree in Civil Engineering. He furthered his education with post-graduate work at Cornell University, Ithaca, N. Y., earning a C.E. degree.

Mr. Shirey entered the service of the Cleveland, Cincinnati, Chicago & St. Louis Railway at Galion, Ohio, as an assistant engineer in 1916, serving in the same capacity at Springfield and Cincinnati, Ohio, from 1920 to 1922, transferring to the Peoria & Eastern Railway at Indianapolis, Ind., in 1923. He entered the service of the Chesapeake & Ohio Railway in the latter part of 1923 as a bridge designer in the chief engineer's office, advancing successively to the positions of designing engineer, assistant bridge engineer, and bridge engineer, from which position he retired on May 31, 1956.

Mr. Shirey became a member of the AREA in 1945 and was a member of Committee 15—Iron and Steel Structures, from 1952 to 1958, when he resigned because of ill health. His pleasing personality made for him many lasting friends, and his engineering knowledge, experience and advice were very helpful to the members of the committee.

Mr. Shirey is survived by his wife, Mrs. Louelle Rogers Shirey, a daughter, a stepdaughter, a stepson, three brothers and two sisters.

J. L. Beckel,
A. R. Harris,
G. W. Salmon,
Committee on Memoir.

Report on Assignment 1

Revision of Manual

E. S. Birkenwald (chairman, subcommittee), J. L. Beckel, R. P. Davis, A. R. Harris, J. C. King, J. F. Marsh, C. H. Sandberg.

Your committee submits for adoption the following recommendations with respect to the Manual:

Pages 15–1–1 to 15–1–42, incl.

SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

Page 15–1–33, Art. 1, Sec. B: In the tensile test requirements for yield point, revise the expression "0.5 tens. str." under Structural Steel and Rivet Steel to read 33,000 and 28,000, respectively, and delete the line reading "but in no case less than 33,000, 28,000."

In the tensile test requirements for elongation in 8 in, revise the expression "1,500,000/tens. str." under Structural Steel and Rivet Steel to read 21 (a) and 24, respectively.

In the tensile test requirements for elongation in 2 in, revise 22 to read 24 (b)

Under the table of tensile test requirements, add the following notes:

(a) Except as modified by Secs. 7 (c) and 7 (d) of ASTM Specifications, designation A 7.

(b) Except as modified in Sec. 7 (e) of ASTM Specifications, designation A 7.

Page 15–1–42, Appendix A: Redefine e_1, e_2, c_1, c_2, r_1 and r_2 as follows:

e_1 = known eccentricity of the applied load at right angles to the neutral axis 1–1.

e_2 = known eccentricity of the applied load at right angles to the neutral axis 2–2.

c_1 = distance from neutral axis 1–1 about which bending occurs to the extreme fiber on the compression side of the bent column.

c_2 = distance from neutral axis 2–2 about which bending occurs to the extreme fiber on the compression side of the bent column (axis 2–2 is at right angles to axis 1–1)

r_1 = radius of gyration of member about neutral axis 1–1.

r_2 = radius of gyration of member about neutral axis 2–2.

Pages 15–6–9 to 15–6–14, incl.

INSTRUCTIONS FOR THE MAINTENANCE INSPECTION OF STEEL BRIDGES

Reapprove without change.

Pages 15–M–21 to 15–M–26, incl.

LARGE RIVETS

Reapprove without change.

Your committee presents as information the following recommendations with respect to the Manual, to be considered for adoption one year hence:

Pages 15–1–1 to 15–1–42, incl.

SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

Pages 15–1–16 and 15–1–17, Sec. A: Substitute the following for Art. 54. Lacing:

54. Lacing and Perforated Cover Plates

(a) Normal Shear

In compression members, the shearing force normal to the member in the plane of the lacing or perforated cover plates shall be obtained by the following formula:

$$V = \frac{P}{100}\left(\frac{100}{l/r + 10} + \frac{l/r}{100}\right)$$

V = Normal shearing force.

P = Allowable compressive axial load on member.

l = length of member, in inches.

r = radius of gyration of section about the axis perpendicular to plane of lacing or perforated covers in inches.

To the shear so determined shall be added any shear due to the weight of the member or to other forces, and the lacing or perforated covers shall be proportioned for the combined shear.

The shear shall be divided equally among all parallel planes in which there are shear resisting elements, whether continuous plates, lacing or perforated covers.

(b) Lacing

Lacing bars of compression members shall be so spaced that the slenderness ratio

of the portion of the flange included between lacing-bar connections will be not more than 40 nor more than 2/3 of the slenderness ratio of the member.

The section of the lacing bars shall be determined by the formula for axial compression in which l is taken as the distance along the bar between its connections to the main segments for single lacing, and as 70 percent of that distance for double lacing.

If the distance across the member between rivet lines in the flanges is more than 15 in and a bar with a single rivet in the connection is used, the lacing shall be double and riveted at the intersections.

The angle between the lacing bars and the axis of the member shall be approximately 45 deg for double lacing and 60 deg for single lacing.

Lacing bars may be shapes or flat bars. For main members the minimum thickness of flat bars shall be 1/40 of the distance along the bar between its connections for single lacing, and 1/60 for double lacing. For bracing members the limits shall be 1/50 for single lacing and 1/75 for double lacing.

The diameter of the rivets in lacing bars shall not exceed ⅓ of the width of the bar. There shall be at least 2 rivets in each end of lacing bars riveted to flanges more than 5 in. in width.

(c) Perforated Cover Plates

Perforations shall be ovaloid or elliptical. The ratio of length (in the direction of stress) to width (perpendicular to the direction of stress) of the perforation shall not be more than two.

The width of perforation shall not be less than 8 in.

The ratio of width of perforation to width of plate shall be not more than one-half.

The clear distance between perforations in the direction of stress shall be not less than the distance between the nearer lines of connecting rivets.

The clear distance between the end perforation and the end of the plate, when the plate is spliced for transfer of compressive stress, shall not be less than one-half times the distance between the nearer lines of connecting rivets; and when the plate is spliced for transfer of tensile stress, it shall not be less than the distance between the nearer lines of connecting rivets. An open perforation may be used at the end of the plate, when not spliced for stress, provided that its length shall not exceed one-half the distance between the nearer lines of connecting rivets.

The thickness of the perforated plate shall be not less than 1/40 of the distance between the nearer lines of connecting rivets or than that required by the formula

$$t = \frac{3\,cU}{44{,}000h\,(c - a)},$$

t = thickness of plate.
c = spacing of the perforations.
U = combined shearing force as specified in Art. 54 (a), in pounds.
h = width of the plate.
a = length of the perforation.
$c - a$ = distance between perforations.

In the case of an asymmetric cross section with perforations in one side only, it shall be assumed that the perforated cover plate and the solid cover plate each take half of the normal shearing force.

The transverse distance at the center of the perforation from its edge to the nearer line of connecting rivets shall not exceed 12 times the thickness of the plate.

For compression members, the ratio of the length of perforation to the radius of

gyration of the half-member at the center of the perforation about its own axis shall not exceed 20, or one-third of the slenderness ratio of the member about its axis perpendicular to the perforation.

The gross section of the plate through the perforation for compression members and the net section of the plate through the perforation for tension members shall be considered as a part of the area of the member.

Your committee also presents as information the following recommendation with respect to the Specifications for Movable Railway Bridges, to be considered for adoption one year hence.

Pages 15–2–1 to 15–2–73, incl.

SPECIFICATIONS FOR MOVABLE RAILWAY BRIDGES

Substitute the following new draft for the "Electric" portion of Sec. F, pages 15–2–47 to 15–2–63, incl.

10. Basis of Specification Requirements

The specification requirements given herein are based on the use of either direct-current or 60-cycle alternating-current motors, and on the use of rheostatic control. When so stipulated, the bridge shall be operated with direct-current motors using variable-voltage control or adjustable-voltage control; in such cases the specification requirements shall be modified as specified by the company.

For the operation of a vertical-lift bridge, the specification requirements are based on the use of one hoisting machine to operate the bridge, or on the use of two hoisting machines mechanically connected. Some special requirements are also given for tower-drive vertical-lift bridges which involve the use of independent hoisting machines at the ends of the span which are operated by alternating-current motors electrically connected by means of synchronizing motors or synchronizing controls to maintain the bridge in level position during operation. When so stipulated, such independent hoisting machines shall be operated by direct-current motors and the bridge maintained in level position during operation by means of special synchronizing controls; in such cases the specification requirements shall be modified as specified by the company.

11. General Requirements for Electrical Installation

The company will state the electric power service which is available and will give the location of the service point at which such service shall be obtained. The contractor shall provide the electrical installation complete from this service point, including all equipment, wiring, and cables, except as otherwise stipulated by the company.

The electrical equipment shall conform to the Standardization Rules of the American Institute of Electrical Engineers and of the National Electrical Manufacturers Association.

The National Electrical Code and local ordinances shall apply to the electrical material, construction, and installation, except as provided otherwise herein.

Insofar as practicable, all major items of electrical equipment throughout, such as motors, control, etc., shall be products of the same manufacturer in order to secure single responsibility and the most satisfactory service. All electrical equipment shall be equal to the best grade of that particular type of equipment made by the leading manufacturers of such equipment.

The contractor shall provide all grounds which may be required for the electrical equipment and service.

In order to prevent deterioration due to corrosion of parts of the electrical installation other than electrical apparatus, all bolts, nuts, studs, pins, screws, terminals, springs, and similar fastenings and fittings shall be, where practicable, of an approved corrosion-resisting material, such as brass or bronze, or of a material treated in an approved manner to render it adequately resistant to corrosion. Hot-dip galvanizing of materials in accordance with the Standard Specifications of the American Society for Testing Materials for such materials shall be considered such approved treatment. Corrosion-preventive treatment of electrical apparatus shall be as stipulated by the company to suit the condition of exposure.

Except as otherwise approved by the company, all metal parts of the electrical equipment, including all conduits, shall be painted as specified for structural steel. For conduits and similar parts where it is not practicable or convenient to apply paint in the shop, the shop coat of paint specified shall be applied in the field, to be followed by the required field coats.

The contractor shall take megohm readings on all circuits installed, and shall furnish a complete report of the results obtained. Defective circuits shall be replaced at the contractor's expense.

12. Working Drawings

In addition to furnishing the data required under Sec. A, Art 12, the contractor shall make complete working drawings for the electrical equipment. The tracings, or translucent copies thereof on cloth, shall become the property of the company after they have been corrected to show the work as constructed. These drawings shall include:

(a) Complete wiring diagrams, giving sizes and numbers of all wires and cables, and the make and capacity of all apparatus, including the sizes of all resistances. Wiring diagrams shall include elementary diagrams showing the general scheme of connections and the general connection of detailed apparatus, and detail diagrams which shall also include the wiring of the switchboards and the control desks. The wire number of each wire and an individual device designation for each electrical device or piece of apparatus shall be shown on the elementary diagram. This device designation shall be used to identify each piece of apparatus on all assembly or installation drawings.

(b) Complete conduit diagrams, which shall show the size of each conduit and the wire number and size of each wire therein, together with a complete one-line schematic conduit diagram. These diagrams shall show the exact location and method of support of all conduits, ducts, boxes and expansion fittings, and each conduit shall be given an individual conduit designation.

(c) Installation diagrams giving locations of all cables, conduits, switchboards, control desks, resistances, switches, lamps, and all other apparatus.

(d) Sectional drawings of all cables showing all component parts and their dimensions, and the materials used.

(e) Drawings showing the general construction and dimensions of all switchboards and the arrangement of all apparatus thereon.

(f) Drawings showing the general construction and dimensions of the control desks and the arrangement of all apparatus thereon.

(g) Certified dimension prints of all electrical apparatus.

(h) Detailed construction drawings of all boxes, troughs, ducts, and raceways other than conduit.

(i) Complete curves for each span-driving motor showing the variation in motor speed and motor currents with output torque, for each point of the controller and within the torque intervals determined by test as specified in Art. 13.

Special apparatus shall be designated by the manufacturer's name and catalog reference.

13. Motor Tests

One span-driving motor of each size or type used shall be subjected to a complete test in accordance with the latest requirements of the National Electrical Manufacturers Association Standards for Motors and Generators.

For alternating-current motors the tests shall also include the determination of the variation in speed and motor currents with motor torques from zero to a driving torque of 225 percent of full load. When stipulated by the company, the speed-current-torque curve shall also be determined for overhauling torque. The speed-current-torque relationship shall be determined for rotor shorted.

For direct-current motors the speed-current-torque relationship shall be determined for each point of the controller from an overhauling torque of 100 percent of full load to a driving torque of 200 percent of full load.

Unless otherwise stipulated by the company, each of the other span-driving motors shall be subjected to a short commercial test. Should the results of this test indicate characteristics differing materially from those of the motor on which the complete test was made, the contractor shall be required, at his own expense, to make the necessary alterations, and to run complete tests to demonstrate the final characteristics.

For tower-drive vertical-lift bridges with synchronizing motors, the synchronizing motors shall be subject to the test requirements for span-driving motors except that where synchronizing motors and drive motors are of the same size and type, only the short commercial test shall be made.

At the option of the company, certified complete test data of a motor of identical design will be accepted in lieu of complete tests of the actual drive motors to be installed.

Each electric motor other than the span-driving motors shall be subjected to a short commercial test.

Except as otherwise approved by the company, all motor tests shall be made in the presence of the company's inspector.

The contractor shall furnish six certified copies of reports of the motor tests and of all tests of other electrical parts which are required to be tested.

14. Motor Torque for Span Operation

The locked-rotor and breakdown torques of a-c motors shall be those specified by the National Electrical Manufacturer's Association.

The torques of the motors shall be as follows:

(a) One-motor installation:
The rated full-load torque of the motor shall be not less than 80 percent of the maximum bridge-starting torque, and the maximum torque peaks that occur when the bridge is accelerated to the required speed, using the specified bridge control, shall preferably not exceed 180 percent of the rated full-load torque of the motor.

(b) Two motor installation, with no provision for operation of the bridge with a single motor:
The two motors jointly shall meet the requirements given in par. (a) for one motor.

(c) Two-motor installation, with provision for operation of the bridge with one motor in not more than 1.5 times the times of openings specified in Sec. C, Art. 6:

The rated full-load torque of one motor shall be not less than 65 percent of the maximum bridge-starting torque, nor 80 percent of the maximum bridge-running torque, not including inertia, and the maximum torque peaks that occur when the bridge is being accelerated to the required speed, using the specified bridge control, shall preferably not exceed 150 percent of the combined rated full-load torque of both motors.

When stipulated or approved by the company, the determination of the size of the motor, according to the preceding paragraph, may be for conditions less severe than the maximum conditions specified in Sec. C, Art. 6.

The maximum bridge-starting torque shall be determined in accordance with the requirements of Sec. C.

15. Number of Motors

If the total power necessary at the motor shaft to move the bridge under Condition A, of Sec. C, Art. 6 at the required speed exceeds 50 hp, consideration shall be given to the use of two span-driving motors, alike, with provision for operation of the bridge by one motor.

Except as otherwise stipulated by the company, the rail locks, the bridge locks, the end lifts of a swing span, and the center wedges of a swing span, shall be operated by one or more motors separate from and independent of the span-driving motors.

16. Synchronizing Motors for Tower-Drive Vertical-Lift Bridges

When synchronizing motors are used on tower-drive vertical-lift bridges to maintain the bridge in level position during operation, the total full-load rated torque of the synchronizing motors on each tower shall be not less than 50 percent of the total full-load rated torque of the span-driving motors on each tower.

17. Speed of Motors

The speed of span-driving motors shall not exceed 900 rpm. The speed of integral-horsepower motors for operation of rail locks, bridge locks and wedges shall not exceed 1200 rpm. For gearmotors of 10 hp or less, fractional horsepower motors and motor generator sets, the speed shall not exceed 1800 rpm.

18. Motors—General Requirements

All motors shall be of the totally enclosed crane, hoist, or mill type, constructed as nearly weatherproof as practicable, except when the size required can not be obtained, or unless otherwise authorized by the company. Motors whose frames tilt during the operation of the bridge shall have ball or roller bearings. Unless otherwise stipulated by the company, motor windings shall be impregnated with a moisture-resisting compound to increase the resistance to excessive moisture. Motors subject to atmospheric conditions shall be totally enclosed, non-ventilated, waterproof. A drain hole shall be provided in the bottom of the frame and, where feasible, heaters shall be built in.

19. Direct-Current Motors

Direct-current motors shall be series, compound, or shunt wound, as required by the performance specified, and shall have commutating poles. If the motors are to be used for dynamic or regenerative braking, they shall perform that function without injurious sparking or temperature rise. Span-operating motors shall conform to the requirements of the Association of Iron and Steel Engineers standards for mill motors.

20. Alternating-Current Motors

Alternating-current motors shall be induction motors, suitable for the service characteristics specified, and conforming to the requirements of the National Electrical Manufacturer's Association. Span-operating motors preferably shall be of the wound-rotor crane type; motors other than span-operating motors preferably shall be of the squirrel-cage type.

21. Heating Requirements for Motors

All alternating-current span-driving motors and motors used directly or indirectly in conjunction with the span-driving motors shall be capable of delivering their rated output continuously for 30 min without exceeding 55 deg C rise in temperature for Class A insulation or 75 deg C for Class B insulation.

All mill-type direct-current motors shall be capable of delivering their rated output continuously for 30 min without exceeding 75 deg C rise in temperature; for crane and hoist motors, the rise shall not exceed 55 deg C.

Motors other than span driving motors shall be rated on the basis of 15 min, provided that their running time during a single opening of the bridge does not exceed 30 sec.

22. Gear Motors

Gear motors shall preferably be provided with an extension of the high-speed shaft to allow hand operation of the mechanism. All gears shall be lubricated by immersion in the lubricant, and effective seals shall be provided to prevent the lubricant from reaching the motor windings. Gear motors shall have not less than a Class II rating as defined by the American Gear Manufacturer's Association and shall carry an AGMA nameplate stating the horsepower, service rating and service factor.

23. Electrically Operated Motor Brakes

The brakes for the span-operating motors, designated in Sec. C, Art. 9 as the "motor" brakes, shall be floor-mounted shoe brakes which are held in the set position by springs with such force as to provide the retarding torques specified in Sec. C, Art. 9. Brake wheels for the motor brakes shall be mounted on the motor pinion shaft, or on a motor shaft extension.

Brakes shall be designed for intermittent duty for the required retarding torques. The brakes shall be designed to hold off when the current is on and to apply automatically when the current is cut off. Brakes for the span operation shall be provided with mechanical or electrical escapements, such that the brakes will not be applied simultaneously.

The brakes shall be equipped with a means for adjusting the torque and shall be set in the shop for the specified torque. Each brake shall be provided with a nameplate which shall state the torque rating of the brake, and the actual torque setting when it differs from the nameplate rating. Shoe-type brakes shall be so designed that it is possible to adjust the brakes or replace the shoe linings without changing the torque settings.

Direct-current brakes shall be released by thrustor units or shunt-coil solenoids. Shunt coils shall have discharge resistors so as to avoid high transient voltage upon opening of the shunt-coil circuit.

Alternating-current brakes shall be released by thrustor units, or motor operators if so stipulated. Thrustor motors exposed to the atmosphere shall be totally enclosed non-ventilated with special weatherproof insulation and conduit box.

For shoe-type brakes the releasing mechanism shall be capable of exerting a force

of not less than 130 percent of the force actually required to release the brake when set at the specified torque setting, and at an ambient temperature of about the minimum expected at the site of the bridge.

The brakes for other motors shall be solenoid-released shoe-type brakes or dry-type disk brakes. Brakes shall have an intermittent rating not less than the full-load torque of the motors with which they are used.

All brakes shall be of a construction which insures uniform wear, and shall be provided with independent adjustments for adjusting lining wear, equalizing clearance between friction surfaces, and adjusting the retarding torque. The friction surfaces shall be of materials which are not affected by moisture. The solenoids, thrustor units, and motor operators shall be moisture proof. All fittings shall be corrosion resisting. Thrustors for shoe-type brakes shall be provided with year-around oil.

Shoe-type brakes shall be provided with a hand release lever permanently attached to the brake mechanism and arranged so that one man can operate the releases easily and rapidly. Means shall be provided for latching the lever in the set and released positions. Disk-type brakes shall be provided with a hand release which can be latched in the released position; the hand release shall automatically reset whenever the brake is energized.

When brakes are located outside of the machinery house, they shall be of weatherproof construction or shall be provided with a weatherproof housing. The housing shall be arranged to permit operation of the hand release lever from without the housing.

If installed on the moving span, the brakes shall operate satisfactorily in any position of the span.

When stipulated by the company, brakes shall be provided with heating elements to prevent the accumulation of moisture and frost.

24. Electrically Operated Machinery Brakes

The brakes for the span-operating machinery, designated in Sec. C, Art. 9 as "machinery" brakes, shall meet the requirements for the "motor" brakes, except as otherwise herein provided.

The brake wheels for the machinery brakes shall be shipped to the manufacturer of the machinery who shall press them onto the shafts.

25. Design of Electrical Parts

Electrical parts, including wiring, switches, circuit breakers, controllers, contactors, and all other apparatus shall be designed for operation of the bridge through successive cycles as specified in Sec. F, Art. 21, and the temperature rise for all such parts under such operation shall not exceed that for which the part is normally rated according to the requirements of these specifications, including those of Sec. F, Arts. 11 and 47.

The allowable drop at the motor terminals shall not exceed 5 percent of the supply voltage at the switchboard.

26. Electrical Control

Separate controllers shall be provided for the span operating motors, the rail lock motors, the bridge lock motors, and the wedge motors.

When there are two main direct-current motors, the control shall be series, parallel, or series-parallel as required, unless the current is furnished by a storage battery, when the control shall be of the series-parallel type.

When the rated horsepower of each span-operating motor is more than 75, the control shall be of the full magnetic type. When the rated horsepower of each span operating

motor is 75 or less, the control shall be of the full magnetic, or semi-magnetic type, as stipulated by the company.

For full magnetic control, all span-operating motor and brake circuits shall be energized by magnetic contactors which are opened and closed by control circuits wired through the master switch and operated by it. Speed control of span operation shall be provided by accelerating contactors.

For semi-magnetic control, the control shall be as specified for full magnetic control, except that the speed control of span operation shall be provided in whole or in part by opening and closing the motor circuits directly by operation of the master switch.

Motor brakes shall be controlled through contacts on the master switches. These contacts shall be so arranged that all motor brakes shall be held released when power is applied to the span-operating motors.

When two motor brakes are used on a hoisting machine, a point of control for each motor brake shall be provided for each direction of travel so that the motor brakes may be applied separately.

For tower-drive vertical lift bridges, two points of motor brake control for each direction of travel shall be provided when two motor brakes are used for the hoisting machine in each tower.

Electrically operated machinery brakes may be controlled through contacts on the master switch, or by a separate switch.

If the machinery brakes are controlled by the master switch, the contacts shall be so arranged that all machinery brakes must be held released when power is applied to the span-operating motors, except when the seating switch is used, as hereinafter described. The sequence of the master switch contacts shall be so arranged that the machinery brakes may be applied by the operator whenever the span is coasting. One point of machinery brake control shall be provided for each direction of travel for all machinery brakes on a hoisting machine.

If the machinery brakes are controlled by a separate switch, they shall normally be set, and shall be so arranged, that they must be released by the operator before starting the bridge. They shall be held in release during the entire operation unless the operator desires to use them while coasting, or unless an emergency condition arises requiring brake power in excess of that offered by the motor brakes, when they may be applied instantly by the operator. This portion of the equipment shall be designed so that it will not be injured if left in release indefinitely. When so stipulated, the brakes shall be provided with not less than three steps of retarding torque to permit partial application of the brakes. The machinery brake circuits shall be independent of the general interlocking system, and there shall be an electrically operated interlocking device which will prevent the use of the main motors and the machinery brakes one against the other, except at the instant of closing.

A seating switch shall be provided for applying the machinery brakes with power still on the motors, in order that the span may be drawn tightly to its seat and held in that position. The seating switch shall be convenient to the operator and shall be hand or foot operated.

For tower-drive vertical-lift bridges one point of control for each direction of travel shall be provided for all machinery brakes. In addition, all machinery brakes shall be applied automatically if the span should attain predetermined skew.

Motors for rail locks, bridge locks, wedges, and other devices associated with the movement of the span shall be controlled through magnetic contactors energized by control switches independent of the master switch.

27. Speed Control for Span Operating Motors

The controllers for all span-operating motors shall provide for speed control of the motors. In general, six steps of acceleration shall be provided. These steps shall be such that the motor torque will differ as little as practicable from the average torque required for uniform acceleration from zero speed to full speed. The controller shall be such that the bridge will start slowly and will accelerate and decelerate smoothly and without excess torque when under the smoothest friction conditions and without wind or other extraneous unbalanced load; and will accelerate and decelerate similarly when the motors are carrying their maximum loads. Separate resistors shall be provided for each motor.

28. Full Magnetic Control

The following features apply to full magnetic control:

(a) Master Switches

Master switches for the span-operating motors shall be cam-operated reversing switches with a single handle, and provided with necessary contacts and contact fingers for operating the magnetic contactors. The contacts and wearing parts shall be easily removable and replaceable. The controller shall provide for speed control of the motors.

(b) Parallel or Series-Parallel Operation

For parallel operation for alternating current, and for constant potential parallel or series-parallel operation for direct current, there shall be separate reversing contactors and separate resistors for each motor. When two motors are connected to one hoisting machine, accelerating contactors shall be common to both motors, unless otherwise stipulated by the company. For three-phase alternating current, each phase shall have its own resistors, so designed as to give balanced current in all three phases. Certain of the acceleration contactors shall be controlled by acceleration relays, such that the torques specified in Art. 14 are not exceeded. When common accelerating contactors are not used, the acceleration contactors shall be so designed, or electrically or mechanically connected, that corresponding circuits in each motor control will be made simultaneously, and that in the event of one motor being cut out, the control for the motor in service will operate satisfactorily.

(c) Acceleration Relays

Adjusting plugs, screws, and nuts, including time-limit adjustments, shall be easily accessible, to allow the relays to be adjusted for the proper timing intervals between acceleration steps. The contacts shall be removable without disturbing the setting of the relays.

(d) Reversing of Motors

Magnetic contactors of the shunt type for reversing the motors shall be installed, with a forward and a reverse pole for each motor conductor.

29. Semi-Magnetic Control

For semi-magnetic control, a master switch of the drum type shall provide for reversing the motors by contactors controlled by contacts on the master switch. The accelerating contacts of the master switch shall carry the secondary current at the step applied without exceeding a temperature rise of 30 deg C, and when the motors are operating at full-load torque, or at stalled torque if it is less. Reversing contactors, and accelerating contactors used in conjunction with the accelerating contacts of the master switch, shall meet the requirements of Sec. F, Art. 36.

For control of motors in parallel the switches shall be interconnected so that all switches will be operated simultaneously by one handle. The controllers shall be so ar-

ranged that the operation of one motor may be cut out without affecting the operation of any other motor.

30. Resistances

Resistors for motor control shall, unless otherwise stipulated, be non-breakable, corrosion-resistant edgewise-wound or punched-grid resistor units. The resistors for the span-operating motors, unless otherwise specified, shall be of a capacity equal to National Electrical Manufacturers Association intermittent cycle rating providing for 15 sec on out of each 45 sec. With the resistors there shall be furnished a steel frame on which the units or sections shall be so mounted as to be free from injurious vibration and to permit free circulation of air around them; and so that any unit or part of a unit may be removed and replaced without disturbing the others. The units shall be insulated from their supports.

For wound-rotor motors with secondary resistance control, the controller shall be so arranged that a small amount of resistance shall always be left in the rotor circuits of each motor. This permanent resistance section shall be adjustable after installation, and shall be proportioned for continuous duty.

31. Limit Switches

For the bridge lock, rail lock, end lift, and wedge motors, limit switches shall be provided which will stop the motors and set the brakes automatically at each end of travel.

For the movable span, limit switches shall be provided which will cut off the current from the main motors and set the brakes so as to stop the span in the "nearly closed" and "nearly open" positions. It shall then be necessary to return the controller handle to the "off" position in order to by-pass the limit-switch contacts and regain control of the span to fully close or fully open the bridge. If so stipulated, relays shall be provided which will prevent the by-pass from functioning until a predetermined time after the brakes have set. Additional limit-switch contacts shall be provided to stop the span in the "fully open" position, and for swing bridges, if so stipulated, in the "fully closed" position. Unless otherwise specified, the "nearly closed" and "nearly open" positions shall be taken to be 6 ft from the "fully closed" and "fully open" positions.

For vertical-lift and bascule bridges, fully seated switches shall be provided, which shall indicate to the operator that the bridge is fully closed.

For tower-drive vertical-lift bridges, "skew" limit switches mechanically connected to the machinery on the two towers, or equally effective switches of other type, shall be provided which will cut off the current from the main motors and set the brakes so as to stop the span whenever it is more than a prescribed amount out of level.

All limit switches exposed to the weather shall be water-tight, and all exposed parts shall be corrosion resisting. Where plunger-type limit switches are used for fully seated switches, they shall be weatherproof and shall be provided with cast-iron enclosures and stainless-steel operating rods.

32. Interlocking

The operating mechanisms of all movable bridges shall be so interlocked that the operation of all devices can be performed only in the prescribed sequence in accordance with the Requirements for the Protection of Traffic at Movable Bridges, Miscellaneous Part, this Chapter.

There shall be provided emergency switches which will free the various motors from the prescribed interlocking in case of an emergency. These switches shall be mounted on

the control desk or on the main switchboard so as to be within convenient reach of the operator. Each such emergency switch shall be sealed in the "off" position.

Auxiliary power units and main power units shall be interlocked to prevent either from being operative while the other is in service.

Motor and machinery brakes shall be provided with limit switches so arranged that the bridge shall be inoperable whenever any brake or combination of brakes shall be released by hand, such that the available braking torque left in service would be insufficient to meet the requirements in Sec. C, Art. 9.

33. Switches

A knife switch or circuit breaker shall be provided as a disconnect for the supply feeder, with a pole for each ungrounded conductor. A similar switch, or a circuit breaker capable of being operated as a switch, shall be provided as a disconnect for each motor, light, signal or other circuit.

Knife switches shall be designed to carry not more than 900 amp per sq in of cross section. Knife switches shall be of not less than 60 amp capacity. Contact shall be maintained by spring pressure, and contact areas shall be silvered.

Toggle and tumbler switches shall not be installed in circuits carrying more than 6 amp. They shall be of not less than 20 amp capacity.

34. Circuit Breakers and Fuses

An automatic circuit breaker shall be placed in the supply line. Wherever practicable, circuit breakers, instead of fuses, shall also be used to provide short-circuit protection for all other wiring circuits. There shall be such a protective device in each motor, brake, light, signal, indicator, or other circuit. When fuses are used, they shall be of a nonrefillable type.

All circuit breakers shall be air-break type for 600 v and less. For circuits above 600 v, either air-break or oil-immersed circuit breakers shall be used as required by the service conditions. Breakers shall have a pole for each wire feeding through the breaker, an overload device consisting of a thermal or magnetic element for each pole, and a common trip. The circuit breaker for the supply line shall also have an undervoltage release, and for alternating current, phase-failure and phase-reversal protection, and shall have an interrupting capacity adequate for the power line. Circuit breakers shall have inverse time limit characteristics so that the tripping will be delayed on normal overloads but will occur instantaneously on abnormal values. The mechanism shall trip free from the handle so that contacts can not be held closed against abnormal overloads or short circuits. The breaker shall have a quick-make and quick-break mechanism. Tripping attachments shall be positive in action. Contacts shall be of the nonwelding type.

Circuit breakers shall not be used for motor overload protection or for limiting the travel of any mechanism.

35. Contact Areas

Line contacts shall be avoided wherever practicable. The current per square inch of contact area shall not exceed 50 amp for spring-held contact, or 100 amp for bolted or clamped contact.

36. Magnetic Contactors

Magnetic contactors shall have an 8-hr rating not less than the current through the contactor when the connected apparatus is operating at rated load. Magnetic contactors shall be of the shunt type, and shall be quick-acting. All contacts shall be well shielded

to prevent arcing between them and other metal parts near. Copper contacts shall have a wipe. The contactors shall have double-break features or shall have magnetic blowouts or equivalent means for rapidly quenching the arc. Contacts shall be designed so as to be readily accessible for inspection and repair. The contactors shall have a minimum number of parts, and all steel parts shall be corrosion resistant. No magnetic motor starters shall be of less than 25-amp rating.

37. Overload Relays

Overload relays, automatic or hand reset as specified, shall be used for overload protection of all motors. They shall be of the thermal type or the magnetic type, and shall be inverse time relays, except for the span-operating motors.

Unless other means are provided for limiting the maximum torque which span-operating motors deliver, an instantaneous magnetic overcurrent relay shall be provided in each motor circuit which shall de-energize all motors when the safe torque is exceeded.

38. Shunt Coils

If shunt coils are used, in particular with brakes and magnetic contactors, the insulation shall be such as to withstand the induced voltage caused by cutting off the current.

39. Instruments

A line voltmeter, ammeters for span-driving motors, and a power bus wattmeter, shall be provided and mounted on the control desk. A voltmeter switch shall be provided which will allow the voltage between any two phases, and also the voltage between any phase and ground, to be measured. Instruments shall be of the rectangular illuminated type and shall be flush-mounted and back-connected.

40. Protection of Apparatus

The electrical apparatus shall be protected from the weather and from accumulations of dirt.

41. Cast Iron in Electrical Parts

Cast iron, unless malleable, shall not be used in switches and small electrical parts.

42. Position Indicators

In order that the operator may know the position of the moving span at all times, there shall be provided synchronous position indicators of the high-accuracy type guaranteed within plus or minus 1 deg. The transmitters shall be geared to the trunnion shafts, counterweight sheave shafts, or machinery shafts, as is most suitable for the particular installation, and the receivers in the control desk shall be geared to the indicators. The gearing shall be arranged so as to give the greatest practicable accuracy in indication.

43. Indicating Lights

There shall be furnished and installed on the control desk indicating lights of suitable colors which will show to the operator the various positions of the bridge, especially the fully closed, fully open, nearly closed, and nearly open positions, and also the closed and open positions of the bridge locks, rail locks, end lifts, and wedges. Indicating lights shall also be provided to show when each span brake is released.

44. Control Desk

The span shall be operated from a control desk on which there shall be located the switches for the span-operating motors and for the lock, end lift and wedge motors;

seating switches; by-pass switches, instruments; position indicators; indicating lights; and all other control devices and apparatus necessary or pertinent to the proper operation and control of the span and its auxiliaries by the operator.

The control desk shall be so located in the operator's house as to afford the operator a clear view in all directions. The desk shall be of cabinet-type construction with a horizontal front section about 36 in above the floor and an inclined rear instrument panel set at such a slope that the meters can be read from average eye level without parallax and without reflection from the glass instrument cover. The plan dimensions of the desk and the arrangement of equipment on the desk shall be such that all control devices are within easy reach of the operator. The top of the desk shall be of ebony asbestos compound not less than 1½ in thick or of a laminated phenolic compound not less than 1 in thick, and of equal physical and electrical strength. Edges shall be beveled and neatly finished. Where stipulated by the company, the top of the desk may be of No. 10 U.S. Standard gage stainless steel with a non-reflecting finish. The horizontal and sloping sections of the top shall be accurately cut to insure a close fit.

The desk frame shall be constructed of sheet steel of not less than No. 11 U.S. Standard gage. All corners and edges of the desk shall be rounded, and the sheet steel shall be reinforced by flanging the metal into angle and channel sections. All connecting sections shall be properly joined by either continuous seam welding or spot welding to provide a rigid free-standing structure. All outside surfaces shall be smooth and without visible joints, seams or laps. The bottom of the desk shall be left open. The supporting flange on the inside of the desk frame at the bottom shall be provided with suitable holes for bolting the desk to the floor. Suitable brackets and angles shall be provided on the inside of the desk to support the top and the equipment mounted thereon.

The control desk shall be provided with hinged doors on the front, and with doors, removable panels, or fixed panels on the back and sides, as stipulated by the company, to suit the requirements of the installation. All doors shall have flanged edges well rounded and shall be flush-mounted on concealed hinges. The hinges shall incorporate jambs to limit the swing of the doors. The doors shall be fitted with sturdy, three-point latches operated by flush-type, chromium-plated handles. The doors shall be assembled accurately and shall have a clearance not exceeding ⅛ in at any point.

In the "off" position, master-switch handles shall be toward the front of the desk. For bascule and swing bridges, the direction of rotation of each master switch shall be such that when it is moved from the "off" position, the span, as seen by the operator, will move in the same direction as the master-switch handle. For double-leaf bascule bridges, the switches shall rotate opposite. For vertical-lift bridges, clockwise rotation shall raise the bridge.

The seating switches, if foot-operated, may be supported to the outside of the desk or may be set in a suitable recess at the bottom of the desk. If a foot recess is used, it shall be rounded at the top to a 1¼-in radius.

All outgoing control connections from the desk shall be brought to suitably marked barrier-type terminal boards supported on straps securely attached to the desk frame. The terminal boards shall be so located that they do not interfere with access to the inside of the desk through the doors. All wires shall be brought from the terminal boards to their respective terminals in a neat and orderly arrangement, properly bunched and tied.

The desk when finished shall be given one coat of moisture-resisting primer and one coat of filler on all surfaces. The outside surfaces shall be given a finished coat of dull lacquer of a color to be stipulated by the company. The horizontal desk top shall not be painted.

The desk interior shall be suitably lighted and the lights controlled from a switch on the desk.

Each piece of equipment and each indicating light on the control desk shall have a properly engraved metal or lamicoid nameplate showing white characters on a black background.

45. Control Panels

All knife switches, circuit breakers, contactors, relays, rectifiers, instrument transformers, and other electrical apparatus for the control of the span and its auxiliaries shall be mounted on one or more control panels located to suit the type of drive selected.

Panelboards shall be of ebony asbestos compound not less than 1½ in thick or a laminated phenolic compound not less than 1 in thick, and of equal physical and electrical strength, with edges beveled and neatly finished. Where stipulated by the company, sheet-steel panels, finished as specified in Sec. F, Art. 44 for the control desk, may be used for the control panels. The panels shall be mounted on substantial steel pipe or angle supports. Apparatus mounted at the bottom of the panel boards shall clear the floor by at least 6 in. Except for front-connected or wall-mounted panels, there shall be a distance of at least 2½ ft between the wall and any of the live parts on the back of the panelboard. Open control panels shall be installed in a separate room provided with a lockable door. Otherwise, control panels shall be enclosed in a general-purpose sheet-metal enclosure.

The control panels shall be designed and installed with a view to the safety of the operator. The equipment shall be so arranged as to be easily reached and operated and to give a neat and attractive appearance.

Control panels shall be either back wired, or front wired. All interconnections shall be made by either copper bus bars or insulated cables of equivalent current-carrying capacity. Bus bars shall be proportioned for a current density of 800 amp per sq in of net cross section, based on the summation of the nameplate ratings of all simultaneously energized equipment connected to the bus. Bus bars and cables shall have right-angle bends and shall run in horizontal and vertical lines only. All wiring at boards shall terminate in terminal strips supported in a substantial manner.

Each piece of equipment on the board shall have a properly engraved nameplate, as specified for the control desk.

46. Control Panel Enclosures

Enclosures for panelboards shall, unless otherwise specified by the company, be general-purpose enclosures conforming to the requirements of the National Electrical Manufacturers Association for Type 1 general-purpose enclosures. The cabinet shall be provided with suitably arranged doors to give access to the front of the board, and either doors or removable panels to give access to the back. The cabinet, including doors and panels, shall be of sheet steel of not less than No. 13 U.S. Standard gage, welded and flanged in a manner that will result in a rigid free-standing structure, and shall be treated to resist corrosion, and finished in the manner specified for the control desk.

47. Electric Wires and Cables

All electric wires and cables shall conform to the requirements of Sec. F, Arts. 11 and 25. The quality of the wires and cables, and their insulation and covering, shall conform to the requirements of the IPCEA-NEMA Standards Publication, Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. When these re-

quirements do not apply, they shall conform to the Standard Specifications of the American Society for Testing Materials.

In general, unless otherwise stipulated, all wires external to the control desk and control panels, shall be rubber-insulated, rubber-jacketed wires, and shall be drawn into metal conduits. The insulation shall be of not lesser quality than Synthetic Rubber, Moisture-Resisting 60 C.

Insulated wire for connections on the backs of control panels and in control desks shall be thermoplastic insulated wire conforming to the Underwriters' Laboratories requirements for Type TW Wire, 600 v, heavy wall.

Insulated wires for connections between the controller and the motor resistance grids shall be all-asbestos switchboard wire, or shall be thermoplastic-insulated asbestos-covered wire conforming to the requirements of the Underwriters' Laboratories for Type TA Wire, 600 v.

No wires smaller than No. 10 B & S gage shall be used except that No. 12 gage will be permitted for fixture drop for service lights, and No. 14 gage for control desk and control panel wiring. All wires shall be stranded.

The ends of all wires No. 8 B & S gage and smaller shall have solderless pressure-type terminals where they terminate at control panels, control desks, terminal strips, lighting panels, junction boxes, and similar points. Similar connections for larger wires shall terminate in pressure lugs or screw-type solderless connectors.

48. Tagging of Wires

Wires shall be numbered and the number permanently marked on durable fiber tags, or on metal or plastic bands so that any wire may be traced from terminal to terminal.

49. Wire Splices

Conductors shall preferably be continuous from terminal to terminal. Where splices are necessary they shall be neatly and carefully made. They shall be made mechanically and electrically secure before soldering. They shall be wrapped with rubber tape and friction tape and painted with waterproof insulating varnish. Splices shall not be inside a conduit.

50. Metal Conduits, Conduit Fittings, and Boxes

Except as otherwise stipulated by the company, conduits shall be hot-dip-galvanized, standard-weight wrought iron pipe not less than ¾ in. in diameter, conforming to current ASTM Specifications, designation A 72. Conduits shall be thoroughly plugged on the inside to remove all fins, scale and other obstructions, and shall be reamed at each end after threading.

The size of a conduit shall be such that the total areas of the wires, including insulation, shall not exceed the percentage of the area of the conduit specified by the National Electrical Code. To lessen the inductive effects, the phase wires in alternating-current motor circuits shall be placed close together in one conduit. The circuits for not more than three alternating-current motors shall be in one conduit.

Suitable condulets, pull boxes, ells, and other fittings shall be used with conduits. Junction boxes may be used where other fittings are not suitable. All boxes, condulets and other fittings shall be of cast iron or malleable iron of sufficient thickness to permit the conduit to be threaded into the fitting, and shall be galvanized. All boxes and other fittings must be weatherproof throughout, in particular at conduit connections, and be free from rough edges and rough surfaces. Large boxes, for which cast iron or malleable

iron is not practicable, may be built of steel plates and angles not less than 3/16 in thick, with all joints continuously welded. All boxes shall be provided with drain holes.

Bends in conduits shall be used sparingly. The total angle of all bends between junction boxes or condulets shall not exceed 180 deg. If the conduit is bent, the radius of the bend to the center of the conduit shall be not less than 8 times the inside diameter of the conduit; this does not apply to factory ells. All conduits shall have drain holes which shall be placed in tee-connections located at the low points of the conduits. So far as possible, all conduits shall be run in lines parallel and perpendicular to the principal lines of the house and structure. All conduits shall be carefully rodded after placing, with a device that will insure that the whole interior surface of the conduit is free and clear of obstruction. The conduit shall be plugged with wooden plugs after being rodded.

Conduits shall be firmly clamped to the structure to prevent rattling and shall be so placed that dirt will not accumulate around them. Supports shall be on not more than 6-ft centers. There shall be at least 1-in clearance between conduits, and at least 4-in clearance between conduits and the supporting structure. Adequate provision for the movement of conduits shall be made wherever conduits cross expansion joints in the supporting structure.

51. Electrical Connections Between Fixed and Moving Parts

Electrical connections for carrying current between fixed and moving parts shall be made as stipulated or approved by the company for each particular installation, and may be by means of flexible cables, collector rings, sliding or rolling trolleys, as generally indicated below, or by other suitable methods.

(a) Flexible Cables

The conductors in flexible cables shall have extra-flexible stranding. In general, the cables shall be connected to terminal strips in junction boxes at which the wiring in conduits terminate. Short cables with relatively small movement of the moving part with reference to the fixed part, such as cables extending from a fixed pier to a fender not rigidly attached to the pier, shall be extra-flexible round portable cable covered with a neoprene jacket or protected with corrosion-resistant metal armor. Long cables with relatively large movement of the moving part with reference to the fixed part, such as vertical cables hanging in a loop between the end of a vertical-lift span and a tower, shall be special, rubber-insulated flexible cables covered with a special neoprene jacket internally reinforced with strong cotton twine to aid in carrying the weight of the cable. Such cables shall be suspended from segmental supports arranged to insure against any sharp bends in the cables as the span moves.

(b) Collector Rings

On swing bridges the connection between the fixed part and the swing span may be made through shoes sliding on circular collector rings attached to the center pivot. The collector rings shall be protected by a removable metal casing.

(c) Sliding and Rolling Trolleys

On vertical-lift bridges, the connection between the lift span and the towers may be made through trolleys with sliding or rolling shoes moving along vertical tracks supported on the towers. For sliding shoes, the track for each conductor shall consist of a flat copper contact strip not less than ¼ in thick supported continuously on a rolled steel section of adequate size and so supported from the tower as to secure a rigid track during operation. For rolling shoes, the track for each conductor shall consist of a grooved copper trolley wire supported at close intervals on a continuous wood strip attached to a

steel section. Means shall be provided to put the trolley wire in tension so as to secure a rigid track during operation. The rolling shoes shall be standard trolley wheels. Twin sliding or rolling shoes shall be provided for each conductor in order to secure good contact during ice and sleet conditions. The twin shoes shall be supported on a trolley arm so designed as to hold the shoes against the track by a spring or by gravity and to provide full contact between the shoes and the track under extreme lateral and longitudinal movements of the span.

52. Electrical Connections Across the Navigable Channel

Electrical connections for carrying current across the navigable channel shall be made as stipulated or approved by the company for each particular installation. They shall generally be made by means of submarine cables but may be made by overhead cables, particularly for vertical-lift bridges. The voltage, the number of conductors in each cable, the size and number of strands in each conductor, the exact construction of the cable, and other data special to the location shall be as specified by the company for each bridge. In general, each cable shall provide a number of spare conductors. Installations shall conform to the general requirements which follow.

(a) Submarine Cables

Submarine cables shall be armored with spiral-wound galvanized-steel-wire armor and, if so stipulated, covered with a neoprene jacket. The individual wires shall meet the requirements specified in Sec. F, Art. 47. Submarine cables may be lead-covered but preferably shall be provided with conductor insulation suitable for submarine use without the use of a lead sheath. Unless otherwise stipulated, they shall be placed at least 5 ft below the bed of the channel. The cables shall be long enough to provide ample slack.

(b) Overhead Cables

Overhead cables shall be provided with a tough rubber jacket, resistant to weather and to aging. The individual wires shall meet the requirements specified in Sec. F, Art. 47. Each cable shall be suspended from a messenger strand at intervals of not more than 18 in. The messenger strand shall be strung with such a sag as required to safely support the entire construction under various conditions of ice, wind, and temperature, appropriate for the location of the bridge. All messenger strands shall be of high-strength material and shall be adequately anchored to steel framework at their ends. Messenger strands, cable hangers, and all accessories shall be protected against corrosion in such manner as to insure a service life not less than that of the overhead cable.

53. Service Lights

A complete electric lighting system shall be installed for the operator's house, machinery house, stairways, vertical-lift span tower tops, signals, machinery, the end lifting and locking apparatus, and at all other points where periodic inspection or maintenance of equipment is required. The system shall be designed and proportioned for the electric lighting service available.

All lamps shall be 75-w lamps unless otherwise specified. All fixtures fitted with lamps smaller than 100 w shall be so equipped that lamps up to 100 w can be used, and the sizes of conductors shall be based on the use of 100-w lamps.

The lights in the operator's house shall be ceiling lights which shall have fixtures finished in polished brass or chromium, with globes not less than 12 in. in diameter fitted with 100-w lamps. In machinery houses, there shall be fixed pendants of suitable length, with porcelain sockets and fire-enameled steel dome reflectors. For exterior light-

ing, vapor-tight, fire-enameled, steel dome reflectors, and weatherproof sockets shall be provided. Enameled steel reflectors shall meet the requirements of the RLM Standards Institute.

Convenience outlets shall be provided in each room of the operator's house; in machinery houses; at the bridge lock, rail lock, and wedge machinery; at submarine cable terminal cabinets; and at all locations where occasional inspection or maintenance of equipment is required. They shall be of the twin-receptacle, 3-wire, grounding type. Outlets exposed to the weather shall be weatherproof, and all exposed parts shall be corrosion-resisting. There shall be furnished two extension cords, each about 30 ft long, which shall be heavy rubber-jacketed cord, with hand lamps and guards fitted with a 100-w lamp and with a plug to fit the receptacles specified above.

54. Navigation Lights

Navigation lights shall be provided in accordance with the requirements of Sec. A, Art. 9.

All navigation light units on the movable span and on fenders shall be capable of withstanding shocks and rough treatment, and shall be completely weatherproof. Unless otherwise specified, the bodies shall be bronze and the lenses shall be fully gasketted. They shall be provided with shock-absorbing porcelain sockets.

55. Circuits

Circuits shall be classified as follows:

a. Power circuits
   (1) Motors
   (2) Other
b. Control circuits
   (1) Span
   (2) Rail locks
   (3) Bridge locks
   (4) Wedges
   (5) Other
c. Lighting circuits
   (1) Navigation lights
   (2) Service lights
   (3) Convenience outlets
   (4) Other

There shall be an independent circuit for each motor, each control circuit, the navigation lights, each group of service lights, and each group of convenience outlets. The use of a common return wire will not be allowed. Each circuit shall be protected and controlled by its own circuit breakers, fuses, and switches, located on the panelboards or at an equally convenient point.

56. Spare Parts

The contractor shall furnish the following spare parts as a part of the electrical equipment:

(a) Six fuses of each size and kind used.

(b) One complete set of stationary and moving contacts for each size of each device.

(c) Twelve indicating light units, complete with lamps, fitted with caps of the several colors used in the installation.

(d) One coil for each size of magnetic contactor used.

(e) One brake coil or thrustor motor for each size of brake used.

(f) For each size of motor: one set of brushes, and one set of motor bearings. For d-c motors; one armature complete with shaft and commutator, one series field coil, and one commutating field coil. For a-c motors: one rotor complete with shaft and slip rings, and one complete set of stator coils.

Report on Assignment 3

Corrosion of Deck Plates

E. T. Franzen (chairman, subcommittee), E. F. Garland, M. L. Koehler, C. A. Roberts, W. M. Thatcher.

This is a progress report, submitted as information.

In order to determine their relative resistance to corrosion by salt brine the following metals, any of which could be used for bridge decks, were selected for tests:

A 7 steel with copper	AREA high-strength structural steel
A 7 steel—plain	A 373 steel
Stainless steel No. 316	Wrought iron 4 D
Corten steel	Aluminum alloy 6061-T6
Mayori R steel	Ingot iron
Manganese-vanadium steel	Aluminum-clad 2014-T6

The above metals have been exposed to the action of salt brine at each of two locations, as follows:

1. In specially built boxes at the AAR Research Center where prescribed amounts of salt brine are sprinkled over the plates at regular intervals.

2. On spacer timbers on the deck of the Huey P. Long Bridge of the New Orleans Public Belt Railway at New Orleans. The exposure is obtained from the salt brine discharged from refrigerator cars over the bridge, the grade and curvature of the tracks being such that a heavy discharge of brine is concentrated on the general area of the spacer timbers.

After an exposure of 10 months the plates at the Research Center were bristle brushed and carefully weighed to determine the loss in weight due to corrosion in that interval of time. Varying losses were recorded, ranging from no loss for the aluminum alloy plates up to a maximum for the ingot iron.

A similar brushing and weighing of the plates on the Huey P. Long Bridge will be made in the near future.

Report on Assignment 4

Stress Distribution in Bridge Frames

(a) Floorbeam Hangers

(c) Truss Bridge Research Project

C. H. Sandberg (chairman, subcommittee), J. E. Bernhardt, E. S. Birkenwald, R. P. Davis, E. T. Franzen, J. M. Hayes, F. M. Masters, J. Michalos, W. H. Munse, G. L. Staley, L. T. Wyly.

Under Assignment 4 (a)—Floorbeam Hangers, your committee submits the following recommendations as information with the view of submitting them for adoption and publication in the Manual next year.

Pages 15–1–1 to 15–1–42, incl.

SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

Page 15–1–11, Art. 31, Sec. A. Insert after "Tension in extreme fibers . . ." the following:

Tension in floorbeam hangers, using rivets in end connections	14,000
Tension in floorbeam hangers, using high-strength bolts in end connections..	18,000

Page 15–1–18. Delete Art. 58. Floorbeams, and substitute the following:

58. Floorbeams and Floorbeam Hangers

(a) Floorbeams

Floorbeams preferably shall be square to the girders or trusses.

(b) Floorbeam Hangers

The main material shall not be coped or notched.

Built-up hangers shall have solid webs or lacing.

The thickness of the main material shall be not less than ½ in.

Forked ends will not be permitted.

Pages 15–5–1 to 15–5–6, incl.

SPECIFICATIONS FOR THE ERECTION OF STEEL RAILWAY BRIDGES

Reapprove with the following revisions:

Page 15–5–4, Art. 12. Insert a new paragraph between the present two paragraphs, reading as follows:

Drifting done during erection shall be only such as to bring the parts in position and not to enlarge the holes or distort the metal.

Report on Assignment 4 (c)

Truss Bridge Research Project

C. H. Sandberg (chairman, subcommittee), J. E. Bernhardt, E. S. Birkenwald, R. P. Davis, E. T. Franzen, J. M. Hayes, F. M. Masters, J. Michalos, W. H. Munse, G. L. Staley, L. T. Wyly.

Your committee submits the following report of progress.

During the past year several significant developments occurred at the truss bridge research project located at Northwestern University, Evanston, Illinois:

1. The hydraulic system was completed.
2. The truss was loaded to design load and a report written on this phase of the investigation.
3. The control (carbon steel) end posts were loaded to determine their ultimate carrying capacity.

Upon completion of the hydraulic system, the loading of the truss became possible, and the success of all the various loading operations attest to a carefully planned and constructed system.

Before loading the end post to failure it was necessary to establish certain relationships of loads and stresses, hence a preliminary series of loadings was performed, as follows:

1. Load was applied to the jacks at each panel point individually to determine the direct and bending stress influence lines in the various members. This also demonstrated the linearity between forces in the members and the applied load as well as the symmetry of the span.
2. Load was applied to all the jacks near each truss separately to determine the distribution of forces to the members of each truss under a simulated single-track loading for comparison with that obtained with both tracks loaded.
3. "Full design load" was applied to all jacks to determine the forces and distribution of stresses in various members. (Design load was that loading which produced design stresses in the end posts.)

With the information obtained in the preliminary investigation the loading of the end post, L_0U_1, to failure was performed with greater confidence. Jack loads of 55 kips at L_1 and L_3 and 40 kips at the other panel points produced design stress in the end posts and closely represented a train loading.

The design load was increased by increasing the 40-kip loads by increments to 60, 70, 80, 90, 100, 110 and to the ultimate load of 120 kips or 1,860,000 lb on the bridge. (The 55-kip loads were increased proportionately to maintain the 55 to 40 ratio.) During each loading increment approximately 250 SR-4 strain gages were read. Deflection of the truss was also determined as well as shortening of the end posts, transverse displacement of the end post and rotations of L_0 and U_1 panel points. Mechanical strain gages were used to determine if there was any slip in the bolted joints.

When a load of 110 kips was applied the presence of yield lines was noted on one of the end posts, and under the 120-kip load yield and Leuders' lines were noted on both end posts. There was no local buckling; rather, integral yielding took place in the cover plates throughout the entire length between gussets. Ultimate load was associated with an increase in deflection with no increase in load; however, the 120 kips was maintained for about 10 min.

The full report of this loading to failure will also include the results of the preliminary loadings.

John F. Ely has been appointed acting director of the project and supervised the various loading operations, assisted by Gerald C. Ward, administrative director. AAR Research Center personnel have taken an active part in the project during the year.

Report on Assignment 6

Preparation and Painting of Steel Surfaces

R. C. Baker, (chairman, subcommittee), E. F. Garland, A. R. Harris, D. L. Jerman, F. M. Masters, N. W. Morgan, R. E. Peck, G. H. Perkins, A. G. Rankin, C. A. Roberts, G. A. Salmon, A. E. Smith.

This is a progress report, submitted as information.

During the past year the director of research of the Steel Structures Painting Council, committee members, and representatives from the AAR research staff inspected paint tests on two bridges of the Seaboard Air Line near Charleston and Jamestown, S. C., three bridges on the Santa Fe near Kansas City, and one bridge on the Chicago Great Western near Byron, Ill.

Some of the paint systems on the Chicago Great Western bridge have failed after being in service one year. Most of these failures were caused by abrasion between the ties and the top flanges of the girders.

The committee is continuing its cooperation with the Steel Structures Painting Council on laboratory and field tests for new materials and methods for the protection of steel surfaces.

Report of Committee 7—Wood Bridges and Trestles

F. E. Schneider, *Chairman*

K. L. De Blois,
Vice Chairman
W. L. Anderson
C. E. Atwater
H. Austill (E)*
C. J. Barhydt
W. W. Boyer
T. E. Brassell
T. P. Burgess
A. W. Carlson
J. W. Chambers
H. M. Church (E)
F. H. Cramer (E)
E. M. Cummings
B. E. Daniels
D. J. Engle
J. T. Evans
J. D. Fraser
W. A. Genereux
S. L. Goldberg
G. J. Grantham
S. F. Grear (E)
R. E. Grieder
J. A. Gustafson
F. J. Hanrahan
J. F. Holmberg
W. C. Howe
R. E. Jacobus
Milton Jarrell
R. P. A. Johnson
J. V. Johnston
W. D. Keeney
J. R. Kelly
L. R. Kubacki
R. E. Kuehner
A. L. Leach
C. V. Lund
W. B. Mackenzie
F. W. Madison
L. J. Markwardt
E. A. Matney
T. K. May
J. W. N. Mays
C. H. Newlin
W. H. O'Brien
W. A. Oliver
D. V. Sartore
B. J. Shadrake
J. G. Shope
A. M. Westenhoff
Lyman Wood
Committee

(E) Member Emeritus.
* Died October 20, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, including recommended revisions ..... page 587

2. Grading rules and classification of lumber for railway uses; specifications for structural timber, collaborating with other organizations interested.
   A report was submitted as information last year with the recommendation that the material be published in the Manual this year. However, since it contains a reference to the National Hardwood Lumber Association's Specification which at present is out of print, this report will have to be held over until an appropriate hardwood specification can be adopted.

3. Specifications for design of wood bridges and trestles. No report for publication. This Subcommittee is working with Subcommittee 1 to review existing Manual documents on design.

4. Methods of fireproofing wood bridges and trestles, including fire-retardant paints, collaborating with Committees 6 and 17 and with the Fire Protection and Insurance Section, AAR.
   Progress report, submitted as information ..... page 590

5. Design of structural glued laminated wood bridges and trestles.
   Progress report, submitted as information ..... page 600

6. Design of timber-concrete composite decks, collaborating with Committee 8.

   A plan for timber-concrete composite decks was adopted last year and now appears in the Manual. Since there have been no comments or criticisms, the assignment is assumed to be completed.

7. Repeated loading of timber structures.

   Progress report, submitted as information ..... page 609

8. Protection of pile cut-offs.

   The committee is continuing to investigate various physical tests as conducted by others but is not prepared to make a report at this time.

9. Hardening of timber bearing surfaces.

   The committee is investigating previously developed information on this assignment but is not yet prepared to present a report.

10. Rules for rating existing wood bridges and trestles.

    The committee has drafted a preliminary set of rules that is now being reviewed with the hope that a report on this assignment can be made next year.

THE COMMITTEE ON WOOD BRIDGES AND TRESTLES,
F. E. SCHNEIDER, *Chairman.*

AREA Bulletin 555, January 1960.

MEMOIR

Col. Huriesco Austill

Col. Huriesco Austill, retired chief engineer of the Terminal Railroad Association of St. Louis and a long-time member of Committee 7, passed away at his home in Mobile, Ala., on October 20, 1959.

Col. Austill was born on May 16, 1884. He became a member of the AREA in 1911, and a member of Committee 7 in 1913, serving as chairman from 1930 to 1938. He was elected Member Emeritus of the committee June 14, 1954.

Col. Austill was also a member of Committee 14—Yards and Terminals, from 1941 to 1949; Committee 4—Rail, from 1947 to 1949; Committee 26—Standardization, from 1930 to 1938; and of Committee 28—Clearances from 1930 to 1938. He retired from railroad service on July 31, 1952.

He leaves behind a great circle of friends and associates who feel deeply the loss in his passing.

Report on Assignment 1

Revision of Manual

D. V. Sartore (chairman, subcommittee), C. E. Atwater, C. J. Barhydt, W. W. Boyer, T. E. Brassell, J. W. Chambers, B. E. Daniels, K. L. DeBlois, Milton Jarrell, C. V. Lund, W. B. Mackenzie, F. W. Madison, E. A. Matney, W. A. Oliver, B. J. Shadrake, A. M. Westenhoff.

In accordance with the secretary's request that all Manual material be reviewed before the Manual is reprinted in 1962, your committee has reviewed approximately one-third of Chapter 7 this year, and offers the following recommended action with respect to the various documents reviewed.

It is your committee's plan to review approximately one-half of the remaining documents in 1961 and the balance in 1962.

Page 7–1–1

AMERICAN LUMBER STANDARDS FOR SOFTWOOD LUMBER

Reapprove without change.

Pages 7–1–1 to 7–1–10, incl.

DEFINITIONS OF TERMS USED IN DESCRIBING STANDARD GRADES FOR LUMBER

Reapprove with the following revisions:

Delete the following definitions: Advanced (or typical) decay, branch knot, closed pitch pocket, cross cutting, cup shake, encased knot, end check, firm knot, hard rot, hollow knot, incipient decay, intergrown knot, loose knot, massed pitch, pin hole, pin knot, pith knot, pith shake, pocket rot, round shake, single knot, soft rot, solid knot, surface check, through check, through shake, tight knot, typical decay, unstable knot and watertight knot.

Combine the definitions of "rot, hard" and "rot, soft" to read "rot. see DECAY"

Under the definition of "decay" make the following revisions: Change "advanced (or typical) decay" to read "advanced or typical decay (soft rot)." After "incipient decay" insert "(hard rot)."

Revise the definition of "beam" to read "Lumber of rectangular cross section, graded with respect to its strength in bending when loaded on the narrow face. See SIZES for dimensions."

Revise the definition of "joists" to read: "Lumber of rectangular cross section, graded with respect to its strength in bending when loaded either on the narrow face as a joist or on the wide face as a plank. See SIZES for dimensions."

Revise the definition of "post" to read: "Lumber of square or approximately square cross section, graded primarily for use as posts or columns carrying longitudinal load, but adapted to miscellaneous uses in which strength in bending is not especially important. See SIZES for dimensions."

Add a definition of "sizes" between definitions of "side cut" and "skip" to read as follows:

"*sizes.* Standard dimensions of dressed or surfaced lumber shall be as follows:

beams and stringers: Nominal thicknesses, 5 in or more. Nominal widths, 8 in or more. Standard sizes, S1S, S2S, S1E, S2E or combinations of sides and edges including S4S, ½ in off each way. Standard lengths, multiples of 2 ft.

joists and planks: Nominal thicknesses, 2 in to, but not including, 5 in. Nominal widths, 4 in or more. Standard thickness, S1S or S2S, ⅜ in off. Standard widths, 4 in S1E or S2E, ⅜ in off; 6 in or more wide S1E or S2E, ½ in off. Standard lengths, multiples of 2 ft.

posts: Nominal sizes, 5 by 5 in and larger. Standard sizes, S1S, S2S, S1E, S2E or combination of sides and edges including S4S, ½ in off each way. Standard lengths, multiples of 2 ft."

Page 7–1–11

STANDARD LUMBER ABBREVIATIONS

Reapprove without change.

Page 7–1–11

NOMENCLATURE OF COMMERCIAL DOMESTIC HARDWOODS AND SOFTWOODS

Reapprove without change.

Pages 7–1–37 to 7–1–41, incl.

SPECIFICATIONS FOR WOOD PILES

Reapprove with the following revisions:

Page 7–1–38. In the second paragraph under Art. 1. General Quality, revise the second sentence to read: "The sum of the sizes of all knots in any foot of length (measured center to center of knots concerned) of the pile shall not exceed twice the size of the largest single knot permitted."

Page 7–1–39. After the last sentence under Art. 9. Diameters, add the following: "The ratio of maximum to minimum diameter shall not exceed 1.2 at a point 3 ft from the butt."

Page 7–1–41. Revise item 8 under Sec. F, to read: "Any exceptions to this specification, such as the entire removal of all inner bark for clean-peeled piles."

Pages 7–3–1 to 7–3–3, incl.

SPECIFICATIONS FOR WORKMANSHIP FOR CONSTRUCTION OF PILE AND FRAMED TRESTLES CARRYING RAILWAY TRAFFIC

Reapprove without change.

Pages 7–3–10 to 7–3–13, incl.

INSTRUCTIONS FOR INSPECTION OF TIMBER TRESTLE RAILWAY BRIDGES

Reapprove with the following revisions:

Page 7–3–11. Under Art. 1 (c), change the phrase, "number of bents" to "number the bents."

Page 7–3–12. Change Art. 4 (d) to read "(d) note all members to determine if any are broken or have moved out of proper position and whether all fastening devices are functioning properly. On ballast-deck trestles, note whether ballast is clean and in full section."

Under Art. 5 (d), change the word "'sashed" to "sash."

Pages 7–5–1 to 7–5–8, incl.

ECONOMIC COMPARISONS; METHODS OF ANALYSIS

Reapprove without change.

Page 7–5–9

RELATIVE MERITS OF OPEN AND BALLASTED-DECK WOOD TRESTLES

Reapprove with the following revisions:

Change Par. 1 to read: "The principle advantages of the open-deck trestle when compared to the ballasted-deck type are:

Lower original cost.

Greater adaptability in temporary or emergency installations.

Lower costs in effecting renewals or repairs under traffic."

Under Par. 2 replace "More satisfactory and safer appearance" with "Greater flexibility for track maintenance."

Page 7–5–10

STANDARDIZATION AND SIMPLIFICATION OF STORE STOCK AND THE DISPOSITION OF MATERIAL REACHING OBSOLESCENCE

Reapprove without change.

Pages 7–M–1 and 7–M–2

SPECIFICATIONS AND DESIGN OF FASTENINGS FOR TIMBER TRESTLES

Reapprove with the following revisions.

Page 7–M–2. Under Art. 12 change "Fig. 8" to "Fig. 4."

Change Art. 14 to read: "Brace plates and washer plates or similar items shall be made of rolled steel to the size and details specified on the plan."

Page 7–M–3

USE OF PROTECTIVE COATINGS FOR IRON AND STEEL FASTENINGS FOR WOOD BRIDGES

Reapprove without change.

Page 7–M–3

SPECIFICATIONS FOR WOOD HIGHWAY BRIDGES

Reapprove with the following revisions.

Change the entire paragraph to read as follows: "It is recommended that the current edition of Standard Specifications for Highway Bridges of the American Association of State Highway Officials be used, subject to the approval of the railway company as to clearances, foundations and construction practices."

Pages 7–M–7 and 7–M–8

RECOMMENDED PRACTICE FOR DESIGN OF WOOD CULVERTS

Reapprove without change.

Report on Assignment 4

Methods of Fireproofing Wood Bridges and Trestles, Including Fire-Retardant Paints

Collaborating with Committees 6 and 17 and with the Fire Protection and Insurance Section, AAR

B. E. Daniels (chairman, subcommittee), W. W. Boyer, D. J. Engle, W. A. Genereaux, R. E. Grieder, J. A. Gustafson, R. E. Jacobus, J. V. Johnston, W. D. Keeney, J. R. Kelly, W. B. Mackenzie, F. W. Madison, L. J. Markwardt, E. A. Matney, J. W. N. Mays.

The investigation of methods of fireproofing wood bridges and trestles has had as one of its aims the writing of performance specifications for fire-retardant coatings to be applied to creosoted wood. Research sponsored by the committee, utilizing wood specimens of a size suitable for laboratory experimentation, has produced a quantity of information. The availability of this information, and the desire for standards designed to assist in the procurement of satisfactory fire-retardant coatings, has resulted in the compilation of the following data intended for ultimate incorporation into a specification.

RECOMMENDED DATA TO BE INCLUDED IN A SPECIFICATION FOR FIRE-RETARDANT COATINGS FOR CREOSOTED WOOD

A. SCOPE

The following data are intended to apply to fire-retardant-coating compositions for use with timber impregnated with creosote or mixtures of creosote with coal tar or petroleum.

B. GENERAL PRODUCT REQUIREMENTS

1. Uniformity

a. All component raw materials of the product shall be thoroughly mixed and dispersed during its manufacture, unless the product is a multi-component system which sets or polymerizes rapidly and requires mixing immediately prior to application.

b. The formulation and quality of the product shall be maintained constant by the manufacturer and shall not be varied without notice.

2. Stability in Storage

The product shall maintain stability at temperatures above 32 deg F, shall not require unusual storage conditions, and shall conform to the requirements of the following paragraphs:

a. In a freshly opened container the product shall reveal no curdling, livering, lumping, decomposition, gelling or any other objectionable characteristic within 12 months after delivery.

b. Separated, settled, caked or thickened materials shall be easily and adequately dispersable with a paddle without change in the quality or properties of the product.

3. Applied Coating

A dry film of the product shall exhibit the following properties:

a. *Adhesion:* The product shall be cohesive and shall adhere to the primary surface and to any secondary supporting surface.

b. *Durability:* The product shall resist water, brine, creosote, mixtures of creosote

with petroleum or coal tar, sunlight, freezing and thawing, general temperature extremes and foot traffic.

c. *Fire Retardancy:* The product shall withstand heat or flames originated by miscellaneous heat sources, including ignited fusees, hot brake shoe splinters, sparks, hot coals or cinders, drops of molten metal and burning debris.

C. APPLICATION REQUIREMENTS AND INSTRUCTIONS

1. Handling Instructions

All precautions for storage and handling prior to and during application of the product shall be stated clearly in an accompanying instruction leaflet prominently displayed on each container, together with complete information and instructions for recommended equipment and materials for surface preparation, thinning, and application.

2. Product Information

All information and physical measurements not specified elsewhere in these specifications, which might assist in the proper handling or testing of the product, shall accompany the instructions and shall include the following:

a. Specific gravity, and weight in pound per gallon, or weight to the nearest 0.1 g of 1 pint of the coating.

b. Recommended maximum wet thickness and calculated coverage of a single-coat application of the coating, unthinned and thinned with recommended proportions of thinner.

c. Measured resultant dry thickness of the recommended maximum wet thickness of a single-coat application.

d. Recommended minimum dry thickness required for fire-retardancy effectiveness.

e. Drying time required between applications, thinned and unthinned.

f. Duration of solvent fire hazard during the drying time of a single-coat application, thinned and unthinned.

g. Drying or curing time required to attain maximum fire retardancy.

h. Recommended spray equipment (gun type, orifice size, spray pattern, pressure, etc.)

i. Solvents and materials which may be used to clean application equipment.

j. Corrosiveness of product to container and spray equipment.

k. Toxicity to humans and animals of the product in the wet and dried conditions.

3. Working Properties

a. The product shall be applicable by brushing, spraying and, if it is a mastic, by trowelling, or it shall be adaptable for spraying, without loss of quality, by addition of a thinner recommended by the manufacturer.

b. A wet film of the product, when applied at the thickness recommended by the manufacturer, shall not show sagging, running, pinholing or other objectionable features.

4. Surface Preparation

Timber surface preparation or treatment shall not be extensive and shall not require unusual equipment, materials or operations.

5. Flammability of Wet Films

a. The evaporation of solvents or other materials from a wet film of the product shall cease to constitute a flammable hazard within 4 hr after application.

b. A film of the product, applied so as to achieve the minimum total dry thickness

recommended by the manufacturer, shall cease to support combustion within 48 hr after application of the final coat.

6. Drying Time

A wet film of the product applied at the maximum wet thickness recommended by the manufacturer, within 36 hr after application and without forced drying, shall be hard enough to allow firm pressure of the thumb against the coated object without rupture of the film or adherence of coating to the thumb.

D. TESTING

1. Specimen Preparation

a. *Wood Selection:* The wood shall be selected from well-seasoned nominal 2- by 6-in boards of Grade B & Btr edge-grained southern yellow pine containing no more than 10 percent heartwood, at least 14 ft in length, dressed on four sides and free from knots, stains, pitch pockets and bark. The maximum width of the annual growth rings shall be no greater than 1/16 in. Edge-grained shall mean that both ends of a board, where the wood has been cut cross sectionally, at least half of the acute angles between lines drawn tangential to the annual rings and lines drawn perpendicular to the broad surfaces of the board shall be no greater than 45 deg.

b. *Sectioning:* The first 6 in of the ends of each board shall be discarded, and the remainder shall be cut laterally into 18-in sections. Each section shall be identified by the board number and by its own number from one end of the board. Each section shall be tested for moisture content at 6-in intervals along its longitudinal axis with an electrical moisture meter employing metal probes which are no shorter than ¼ in. The moisture content of a section shall be greater than 8 percent and less than 15 percent. The sections shall be protected from checking or loss of moisture, preferably by storage in a cold humidified atmosphere. A section which has checked shall not be used as a test specimen.

c. *Preservative Treatment:* The dimensions of an 18-in section shall be measured to the nearest 0.01 in and the volume calculated to the nearest 0.001 cu ft. Each section shall be weighed to the nearest gram before preservative treatment. The creosote solutions and treating methods employed for impregnation of the sections shall be prescribed by the purchaser. After preservative treatment, each section shall be allowed to drain freely for 24 hr, wiped clean and weighed to the nearest gram. The preservative retention shall be calculated in pounds per cubic foot to the nearest 0.01 lb per cu ft, using the previously obtained dimensions and volume calculations, and the resultant figure shall be called "initial retention." The treated sections shall be stored for a minimum of 30 days or a maximum of 60 days, at approximately 75 deg F and 50 percent relative humidity, prior to a coating application or any form of testing. Immediately prior to preparation of a section for use in testing procedures, the section shall be weighed to the nearest gram, the net preservative retention shall be calculated, and the resultant figure shall be called "test retention." All treated or untreated specimens used in a test shall be subjected to identical pre-test storage conditions.

2. Fire Tests

a. Testing in Fire-Test Cabinet

(1) *Apparatus:* The fire-test cabinet shall be a rectangular insulated chamber measuring 31 in high, 10 in wide and 12 in deep. In order to suspend the specimen in the fire-test cabinet, a supporting rod shall be affixed horizontally 1 in from the tops of opposite walls of the cabinet. For draft control, the 2-in bottom section of the cabinet

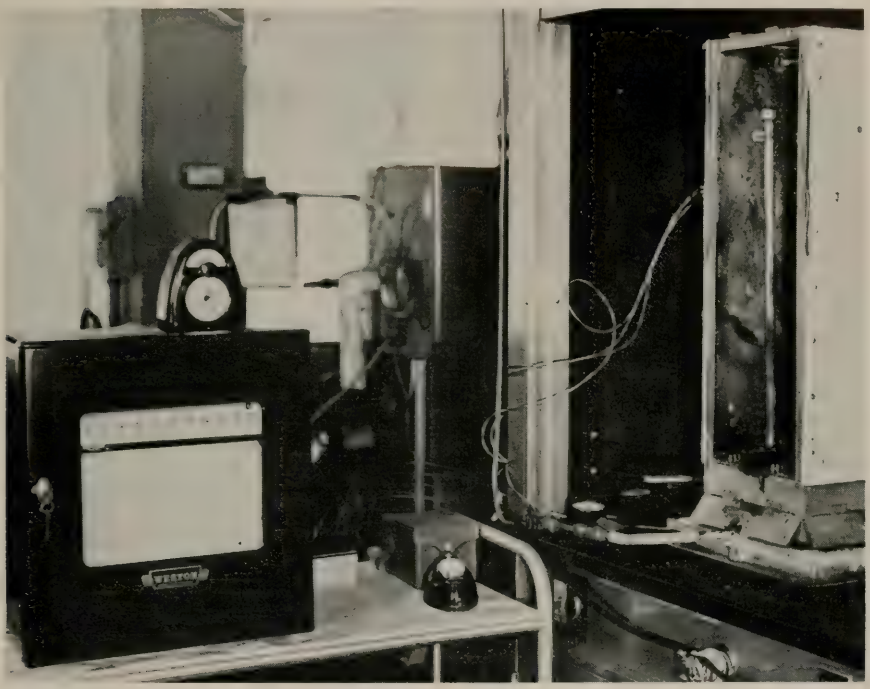


Fig. 1—Fire test cabinet and temperature recorder.

shall consist of louvers which can be raised 90 deg. Two pairs of ungalvanized iron pipe with ⅜ in internal diameter, each pair vertically parallel and separated by 3 in between their longitudinal axes, shall be fastened to opposite sides of the cabinet. Orifices of 1/32 in diameter shall be located in a straight line at 1-in intervals, for 20 in along each pipe, beginning 1 in from the capped end. The cabinet shall be equipped with a removable door fitted with viewing ports covered with mica sheet. A pilot-flame orifice shall be installed at the bottom of one pipe at each side of the cabinet.

(2) *Fuel:* Bottled liquid-petroleum gas, with a minimum propane content of 95 percent, shall be supplied to the burner pipes at the rate of 0.4 cu ft per min or approximately 60,000 Btu per hr during the course of a specimen ignition. The flames shall extend approximately 4 in horizontally from the orifices and shall be of a definite yellow color.

(3) *Specimen Selection and Position:* The test specimen shall be selected by the procedures specified under Sec. D, Art. 1, coated with a film of uniform thickness, allowed to dry or cure completely, and shall be suspended vertically in the fire-test cabinet at the initiation of the test. The broad faces of the specimen shall parallel the two pairs of burner pipes at a distance of 3 in from the orifices, with the top end of the specimen on a level with the top orifices.

(4) *Test Procedure:* A specimen shall be positioned in the fire-test cabinet with the door closed and the pilot flames lit. The ignition of the specimen shall be effected by

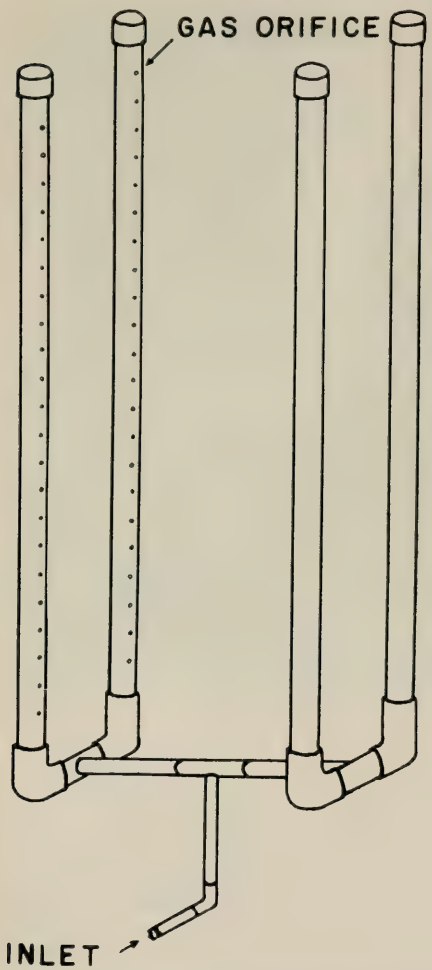


Fig. 3 (above)—Specimen suspended in fire test cabinet.

Fig. 2 (left)—Construction of fire test cabinet burner.

quickly opening the fuel valve to the required setting and allowing the flames of the ignited gas to be directed against the specimen for 5 min. The duration of self-sustained flaming after ignition shall be recorded and designated as "free-burning time." The period after which flaming has stopped and glowing occurs shall be recorded and designated as "glow time." The free-burning interval shall be terminated for one of the following reasons:

(a) A maximum free-burning time of 30 min shall have passed.
(b) During the 30-min free-burning period it is judged that the flames are merely flickering or flashing and constitute practical self-extinguishment, or that small flames are being sustained only at the ends of the specimen.

If at the end of the 30-min free-burning period, flaming continues at a rate requiring the use of an accessory extinguishing agent, the flames shall be extinguished with a fire-extinguishing gas.

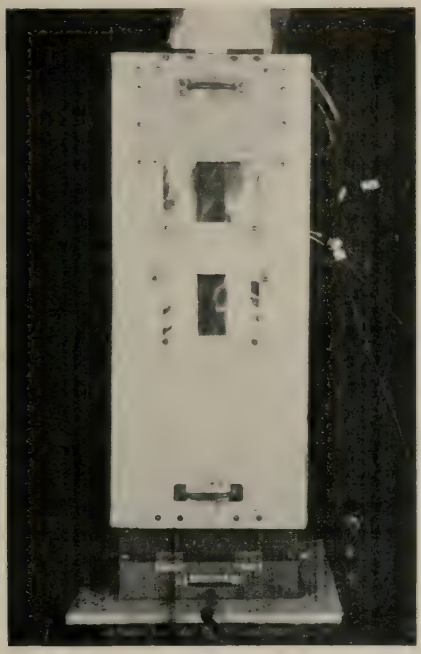


Fig. 4—Ignition of specimen in fire test cabinet.

The test may be conducted in a well insulated laboratory fume hood or on a table placed under an insulated canopy. Both the fume hood and the canopy shall be equipped with efficient, safe smoke-exhaust fans. The exhaust fans shall be operating prior to ignition of the specimen.

(5) *Observations:* The specimen shall be attentively observed during the ignition and the free-burning periods, and specimen appearance, coating condition and flame activity shall be recorded. Relative flame activity during the free-burning period and at its termination shall be described with the following terminology:

Vigorous—Entire specimen flaming with little or no apparent diminishment of combustion rate.

Very Strong—Approximately 75 percent of specimen flaming, with apparent combustion rate slowly decreasing.

Strong—Approximately 50 percent of specimen flaming, with apparent combustion rate decreasing.

Mild—Approximately 25 percent of specimen flaming, with apparent combustion rate decreasing rapidly.

Scattered—Small areas of flaming where creosote wicking may be occurring or a heat trap may be located.

Torching—Flames occurring with jet-like activity at points of coating rupture or specimen checking.

Flickering—Small, virtually extinguished, flames at a few discrete points.

Flashing—Spontaneous extinguishment and reignition of an area.

After the free-burning period, the specimen shall be allowed to remain in the fire-test cabinet, with the door removed, until glowing has ceased. The time required for the cessation of glowing shall be recorded as "glow time."

The burned specimen shall be weighed to the nearest gram, with the coating removed and wood char intact, not less than 24 nor more than 36 hr after the free-burning period. The specimen shall be cleaned of char immediately, without damage to the wood, and weighed again. The differences between the two weighings shall be recorded as the weight of the char, and shall be calculated in pounds per cubic foot of volume of the unburned specimen. The difference of weight of the specimen before burning and after being burned and cleaned shall be recorded as its total weight loss, and shall be calculated in pounds per cubic foot by volume of the unburned specimen.

The thickness of the burned, cleaned specimen shall be measured to the nearest 1/64 in on its longitudinal axis at a point 6 in from the end which was topmost in the fire-test cabinet. The difference between the thickness of the specimen before and after burning shall be divided by two and recorded as char depth.

Other observations which shall be recorded are:

(a) Coating thickness and weight, wet.
(b) All defects found in a coated or uncoated specimen before a fire test.
(c) Blistering, fissuring, rupturing, intumescence, sloughing or other effects exhibited by a coating during a test, and the elapsed time before their occurrence.
(d) Relative extent of preservative bleeding during a fire test.
(e) Relative amount of smoke production during a fire test.

(6) *Acceptance Criteria:*

(a) The specimen shall be totally or virtually self-extinguished within the 30-min free-burning period.
(b) The total weight loss of the specimen shall not exceed 30 percent, or 15 lb per cu ft by volume of the unburned specimen.
(c) The char depth shall not exceed ⅛ in. The char shall be evenly distributed with no occurrence of cupped areas.
(d) The quantity of char shall not exceed 2.5 lb per cu ft by volume of the unburned specimen.
(e) Glowing shall cease within one hour after termination of the free-burning period.
(f) The coating shall remain intact upon the specimen throughout the ignition, free-burning and glow periods, and shall exhibit no sloughing, spalling or peeling.
(g) The dry thickness of coating necessary to fulfill the requirements of these criteria shall not exceed ⅛ in.
(h) The performance of a minimum of three specimens, prepared in an identical manner, shall conform to the stipulations of the acceptance criteria.

b. Fusee Test

(1) *Construction:* The fusee test apparatus shall consist of two specimens selected by the procedures specified under Sec. D, Art. 1, and a section of gypsum or other fireproof insulating board measuring 18 by 6 by 1 in. The two wood specimens shall be coated uniformly with the same thickness used for specimens tested in the fire-test cabinet, and allowed to dry or cure completely. The coated specimens shall be joined to-

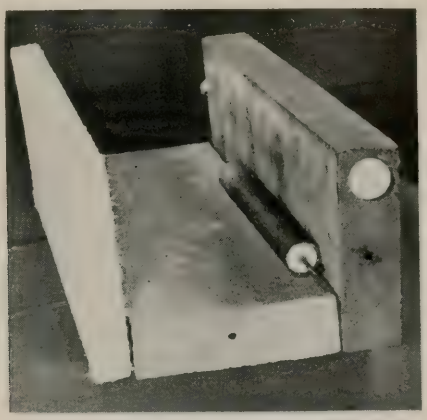


Fig. 5—Fusee test trough.

gether lengthwise in the shape of an "L", forming one side and the bottom of a flat-bottomed trough. The trough shall be completed in a "U" shape by joining the insulation board to the bottom specimen. The specimens need not be nailed or fastened together. The bottom specimen may be laid flat, with the other coated specimen and the insulation board standing on their edges and placed flush against the edges of the bottom specimen.

(2) *Procedure:* The trough shall be situated in a laboratory fume hood, with the exhaust fan operating. A 10-min fusee shall be ignited and laid snugly in the corner formed by the junction of the two coated specimens. When the fusee has been consumed, the duration and intensity of residual flame activity shall be recorded.

(3) *Acceptance Criteria:*

(a) Flames shall be totally or virtually self-extinguished within 10 min after the fusee has stopped burning.

(b) The coating shall not flake, peel, crumble, slough or exhibit any other effects which result in the exposure of the wood substrate.

(c) Glowing shall have ceased within 30 min after flaming has stopped.

c. Accelerated Weathering Test

(1) *Apparatus and Specimens:* When a coating shall have conformed to the standards of the fire tests during initial testing, it shall be used to prepare five additional specimens which shall be approximately identical to those which had been tested. After thorough drying or curing, the specimens shall be exposed to artificial sunlight and simulated rainfall in a weathering device described in ASTM Specifications, designation E 42.

(2) *Procedure:* Each specimen shall be positioned vertically in the weathering device, with one of its broad surfaces facing the light source. The same surface shall face the light throughout the test. The test shall be terminated after an accumulated light-exposure time of 1000 hr or when, at any prior time, the coating is judged to have failed. The decision of apparent coating failure shall be subjective and shall be based on the appearance of excessive blistering or softening, or exposure of wood by sloughing, peeling, flaking, cracking or other effects. The test shall be conducted in accordance with the following program:

(a) The specimen shall be exposed to artificial sunlight at all times during the operation of the weathering device, except for such times as shall be required for the restriking of the carbon arc.

(b) The specimens shall be mounted, with a face-to-face diameter of 30 in, on a circular rack which rotates at the rate of 1 rpm. A water spray in the weathering device shall operate for 18 min at intervals of 102 min, so that during each 2 hr of light radiation the specimens shall be exposed to water for 18 min. In this manner each specimen shall receive approximately 2.5 to 3.0 min direct water spray during each 2-hr radiation period.

(c) Exposure in the artificial weathering device shall be undertaken daily, for a total of 90 hr within 5 days. At the end of each 90 hr of exposure, the specimens shall be allowed to cool at room temperature for a minimum of 2 hr and then placed for 65 hr in a cold chamber adjusted to maintain a temperature of −20 deg F. At the end of the cold period, the specimens shall be allowed to warm at room temperature for a minimum of 2 hr before again placing them in the weathering device. Extreme caution shall be observed during all handling and transfer operations involving a specimen so as not to modify its condition.

(3) *Acceptance Criteria:* At the termination of the weathering program, if failure has not occurred, the specimens shall be subjected to the fire tests and shall be rated by the acceptance criteria of those tests.

d. Brine Resistance Test

(1) *Apparatus:* An assembly shall be arranged consisting of a stop-cock-controlled funnel and a small container equipped with an overflow outlet. The container shall measure 4 in on all sides, with an overflow tube of a minimum ⅛ in diameter leading out from a point 1 in below the top edge, and shall be composed of waterproof and chemical-resistant materials, such as glass, rubber or plastics. The funnel shall be large enough to contain a minimum of 500 ml of liquid and shall be placed vertically over the container.

(2) *Specimen Selection and Preparation:* An 18-in preservative-treated specimen shall be selected by the procedures outlined under Sec. D, Art. 1, discarding 4½ in of each end of the specimen. The remainder of the specimen shall be sawn laterally at 2-in intervals, yielding four sections, each of which shall be coated with a different product. A section shall measure 2 by 1⅝ by 5⅝ in and shall be weighed to the nearest 0.1 g. A uniform continuous coating film of the same thickness used for the fire-test specimens shall be applied to all surfaces of the section, beginning at a point 1 in from one end. The thickness and weight of the wet coating application shall be recorded, and the coating shall be allowed to dry or cure completely.

(3) *Test Procedure:* The container shall be filled to the overflow outlet with a 10 percent sodium chloride brine solution. The funnel also shall be filled with the brine solution. The test shall be conducted at room temperature, 75 to 80 deg F, and the brine shall be maintained at that temperature throughout the test. The coated end of a specimen shall be immersed at approximately a 45-deg angle in the container, with the wider side facing upward, and with the uncoated area of the opposite side resting on the edge of the container. No more than 4 nor less than 3½ in of a coated side shall be below the surface of the solution. The tip of the funnel shall be positioned 1 in above the center of the line between the coated and uncoated areas of the specimen. At the start of the test, the stop cock shall be opened sufficiently to allow drops of brine to fall at the rate of approximately 10 drops per minute, striking the specimen at the midpoint of the line between the coated and uncoated areas. Dripping and immersion shall be continuous for 300 hr. The effluent from the specimen container shall be collected in any suitable

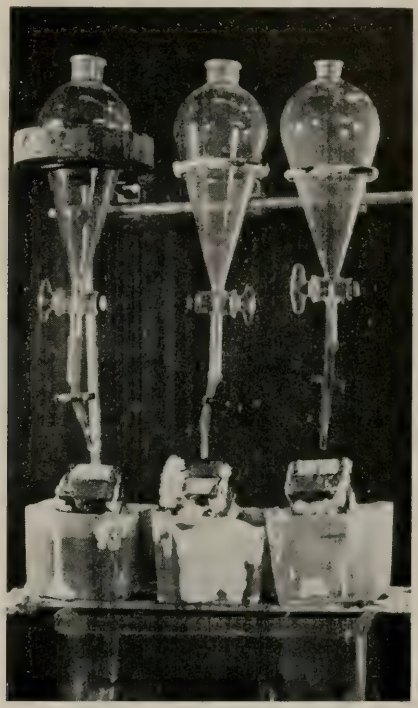


Fig. 6—Termination of brine resistance test.

container and discarded. At the end of 300 hr, the brine solution in the specimen container shall be examined for discoloration and for materials which have separated from the coating. The specimen shall be observed for blistering, fissuring, crumbling or other effects.

(4) *Acceptance Criteria:* The specimen shall be examined immediately at the end of a test and at a time one week after the test. Fissures in the coating shall be no wider than hairline cracks. Blisters shall be no larger than ⅛ in. in diameter. The size of coating particles which may have dropped from the specimen shall not be large enough to expose the wood substrate. Gentle teasing of the coating with a knife point shall not result in easy dislodgement of coating particles. The dry thickness of the coating at any location on the specimen shall not have decreased by more than one-fourth of the original dry thickness. Discoloration of the brine solution and the presence of coating particles in the container shall indicate possible leaching or solvation of the fire-retardant constituents of the coating.

e. Foot Traffic Test

A specimen shall be selected and prepared in the same manner as the specimens used for the fire tests, with the same thickness of coating applied. The coating shall be allowed to dry or cure completely.

(1) *Procedure:* The specimen shall be heated for 1 hr at 140 deg F in an electric oven. The specimen shall then be removed from the oven and immediately laid flat on one of its broad surfaces on a protected area of the floor. The uppermost surface shall

be stepped upon by a person weighing no less than 150 lb. His entire weight shall be concentrated on the specimen for 1 min, during which time he shall execute a 45-deg turning movement of his foot upon the coating.

(2) *Acceptance Criteria:* The coating shall not exhibit tearing, and shall not be lifted from the wood substrate by adhesion to the shoe used to exert pressure. Should these or other objectionable effects occur, the test shall be repeated using mineral aggregate or similar material spread over the specimen surface while the coating is still wet.

During repetition of the test, the surface material shall be firmly held by the coating and shall not be easily dislodged.

Report on Assignment 5

Design of Structural Glued Laminated Wood Bridges and Trestles

J. A. Gustafson (chairman, subcommittee), T. E. Brassell, T. P. Burgess, J. W. Chambers, K. L. DeBlois, J. T. Evans, R. E. Grieder, F. J. Hanrahan, J. F. Holmberg, W. C. Howe, R. E. Jacobus, J. H. Kelly, T. K. May, J. W. N. Mays, W. A. Oliver, D. V. Sartore, Lyman W. Wood.

This is a progress report, submitted as information.

An investigation has been started at the AAR Research Center to determine the static and repeated-load strength of glued-laminated stringers. Sixteen full-size stringers of Douglas fir, 7 in by 16¼ in by 13 ft 10 in, are being used in this study. The shear strength and the flexural strength will be determined as well as the effect of scarf joints. A report on the results of this investigation will be presented at a later date.

The ultimate static strength of a large glued laminated girder was determined at the AAR Research Center, and a report on the test is included herewith.

Ultimate Static Strength of a 52-Ft Glued Laminated Timber Girder

A. DIGEST

The ultimate static carrying capacity of a 9-in by 36-in by 52-ft laminated timber girder was determined in the AAR Engineering Research Laboratory on August 3, 1959. In this investigation the extreme tensile and compressive fiber stresses at the center of the span, the shears at one end of the span and the deflection at the center were continuously recorded by oscillographs. In addition, the vertical deflection at the center of the span was determined by reading with a level a scale mounted on the beam.

The ultimate load was 66,000 lb per jack, which is equivalent to a calculated flexural stress of 8150 psi. The measured deflection was 7.69 in.

B. INSTRUMENTS AND EQUIPMENT

Two 6-in SR-4 wire strain gages were cemented to the top of the girder and two similar gages were placed on the bottom. One strain gage rosette was placed on each side of the girder 3 ft from the center line of the bearing on the neutral axis. A sliding wire potentiometer was placed under the beam at the center to determine the deflections. All strain gages and the potentiometer were then connected to the electronic strain gage equipment, shown in Photograph 1. Piano wire was stretched from one end of the beam to the other at the center line of bearings, with a vertical scale mounted on the girder at the center to determine the vertical deflection at the neutral axis. A surveyor's level mounted on a tripod was used to read these deflections visually.

The equipment used in this investigation consisted of four hydraulic jacks for applying the load and the load-measuring equipment. The jacks and load-measuring equipment were made by Alfred J. Amsler and Company, Schaffhouse, Switzerland. The hydraulic jacks have lapped ram pistons with spherical seats at both ends, insuring concentric loads. Precision machining reduces friction so that the oil pressure is an accurate indication of the load. The jacks have a ram stroke of about 4½ in.

The oil pressure for the 25-ton jacks used to produce initial deflection was supplied by the minimum-load pump of a pulsator and measured with the pressure gage on the pulsator. This pulsator is normally used for repeated-load tests in which specimens are subjected to pulsating loads varying from a minimum of 2000 or 3000 lb to the maximum capacity of the jack, but it can be used for static loads by keeping the minimum load equal to the maximum load.

The oil pressure for the 50-ton jack used for final loading was supplied and measured by a pendulum dynamometer. The calibration of the pendulum dynamometer and 50-ton jacks was checked prior to the tests. The load applied to the jacks is measured by the pendulum dynamometer in which the applied pressure acts on a measuring piston which actuates a pendulum. A higher pressure on the piston is balanced by a higher swing of the pendulum. This movement is transmitted to a pointer which indicates the load. The measuring piston is constantly rotating about its own axis, thereby practically eliminating friction. The speed of the ram is controlled automatically, and in these particular tests the ram speed was 1 in per min, thus producing a 1-in deflection of the girder in 1 min. This ram speed is well below the maximum speed of 1.3 in per min for girders of this size, as recommended by ASTM designation D 198–27.

C. TEST GIRDER

The 9- by 36-in test girder was fabricated by Rilco Laminated Products Company in its plant at Albert Lea, Minn. It consisted of 22 laminations.

The lumber was Coast-Type Douglas fir structurally graded to meet the requirements of the West Coast Lumbermen's Association Glued Laminated Standards. All scarf joints were pre-glued with straight resorcinol adhesives in high-frequency pre-gluers. The full-length laminations were then surfaced to the net depth prior to glue spreading, layup, clamping and curing. The adhesive used was room-temperature-setting phenol-resorcinol, manufactured by Koppers Company, Inc., and designated as "1288". The member was surfaced on both wide faces and end trimmed, and the standard surface sealer and end sealers were applied prior to shipping to the AAR Laboratory. The scarf joints were straight beveled with a slope of 1 in 10.

D. TEST PROCEDURE

The girder was placed in the loading frame, as shown on Fig. 1 and in Photographs 3 and 4, with one end fixed and the other end resting on an expansion roller, for a span length of 50 ft.

The top of the girder at each end was held laterally by steel straps fastened to the supporting beam. The top part of the girder near the third points was supported laterally in a similar manner, as shown in Photographs 3 and 4. The steel traps at the third points were kept loose so they would not produce any restraint to the girder against possible longitudinal movement of the laminations.

Two 50-ton hydraulic jacks were placed on top of the beam 10 ft apart, as shown in Fig. 1, and connected to the pendulum dynamometer. Two 25-ton jacks were placed on top of the beam 1 ft 8 in from the center line of the span, as shown in Fig. 1, and connected to a pulsator.

The girder was then loaded with the 25-ton jacks to produce a deflection of slightly over 2 in. The load was maintained by the 25-ton jacks until the rams of the 50-ton jacks could be turned down against the girder, which required about 1 min. The load was then applied continuously by the 50-ton jacks until a deflection of about 6 in was reached, with strains and deflections continuously recorded by the electronic equipment and visual deflections usually taken every 2000 lb per jack. Under a load of approximately 55,000 lb per jack and a unit stress of approximately 6800 psi a slight longitudinal splinter occurred in the bottom lamination on one edge. Since the full extent of travel of the rams on the 50-ton jacks had just about been reached, the rams on the 25-ton jacks were screwed down against the beam and the load transferred to these jacks. The 50-ton jacks were then reset and the load again transferred to them. The load was again applied to the girder by the 50-ton jacks, and an ultimate load of 66,000 lb per jack was reached, which caused complete failure of the beam, as shown in Photographs 5 and 6.

E. TEST RESULTS

The pertinent data secured during this test are shown on Figs. 2, 3 and 4.

Fig. 2 shows the plot of recorded deflections as related to the calculated flexural stress. These deflections are those obtained with the surveyor's level, and agree closely with those obtained with the potentiometer and read from the oscillograph record. It can be seen that the stress at the proportional limit was determined to be 6420 psi with a deflection of 5.56 in. The resulting modulus of elasticity is 2,270,000 psi. At the ultimate load of 66,000 lb per jack the calculated flexural stress is 8150 psi, and the measured deflection was 7.69 in. In addition to the unit stress resulting from the applied

load, a unit stress of 150 psi was added due to the dead load of the girder, resulting in an ultimate flexural stress of 8300 psi.

The recorded flexural strains are shown on Fig. 3 for the top and bottom of the girder. The compressive strains shown are the average strains of two gages, and similarly, the tensile strains are the average of two gages. It can be seen that both the compressive and tensile strains are linear with respect to the calculated stress and the applied load. At a load of 54,000 lb per jack the average compressive strain was 0.02890 in per in, and the average tensile strain was 0.002710 in per in, indicating a slight shift of the neutral axis. The calculated stresses at this load and based on this location of the neutral axis are $f_t = 6890$ psi and $f_c = 6430$ psi. The resulting moduli of elasticity are $E_c = 2{,}230{,}000$ psi and $E_t = 2{,}540{,}000$ psi. Strains at and near the ultimate load are not shown.

The recorded shearing strains are shown in Fig. 4, and are the averages of recorded strains on each side of the girder. Here also, the strains indicate a linearity with respect to the calculated stress and the applied load. At a load of 54,000 lb per jack the average recorded shearing strain was 0.00196 in per in. The calculated shearing stress at this load is 250 psi, and the resulting modulus of rigidity is 128,000 psi.

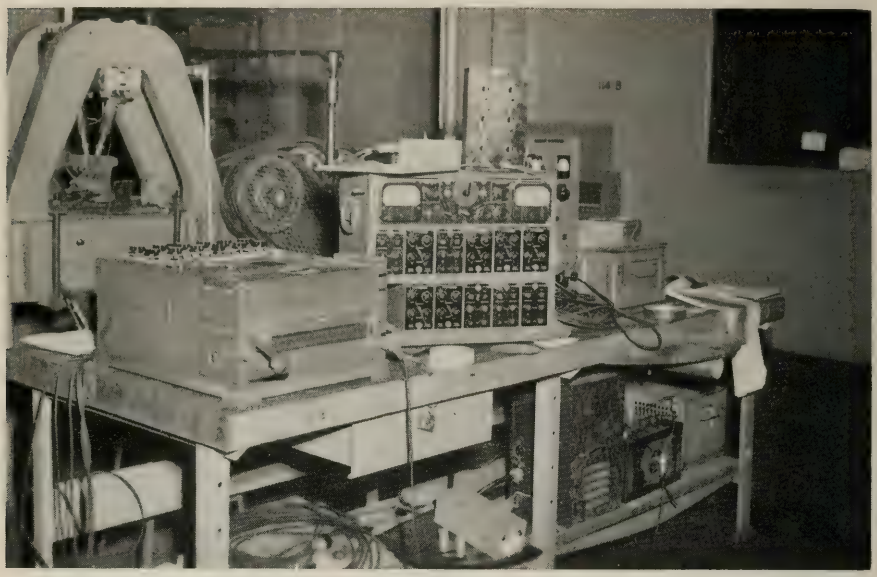
Failure of this girder was associated with a rupture of the tensile fibers, as shown in Photograph 6. There was also longitudinal cracking near the bottom of the girder with some of these cracks extending to one end.

Upon completion of the investigation at the AAR Research Laboratory, the center portion of the girder was shipped to the Forest Products Laboratory where compression tests were made on small clear specimens cut from the bottom and top lamination. Table 1 shows the results of these tests.

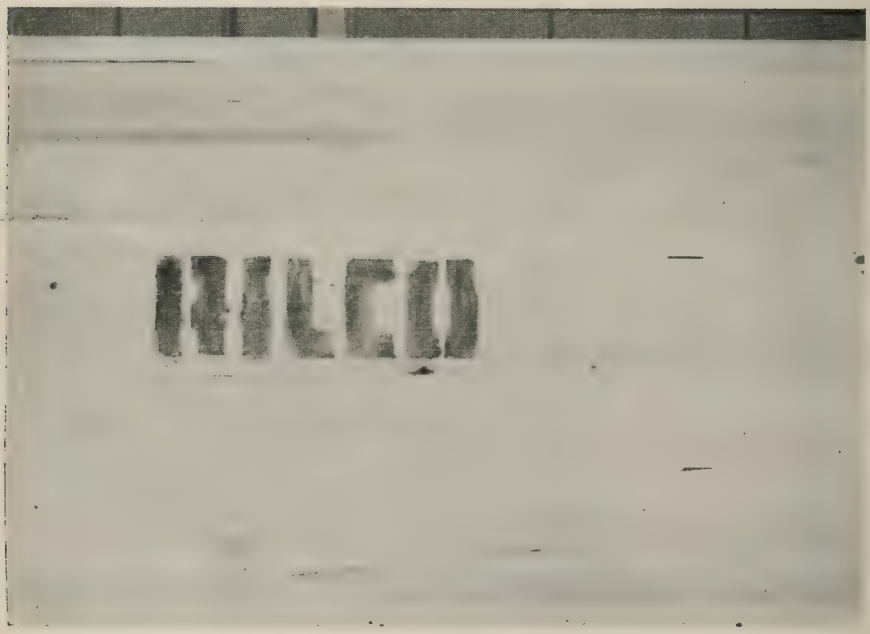
TABLE 1—RESULTS OF COMPRESSION TESTS[1] OF 1- BY 1- BY 4-IN SPECIMENS CUT FROM TOP AND BOTTOM LAMINATIONS OF RILCO DOUGLAS-FIR BEAM TESTED AT AAR LABORATORY ON AUGUST 3, 1959

Specimen No.	*Stress at Proportional Limit PSI*	*Maximum Stress PSI*	*Modulus of Elasticity 1,000 PSI*	*Moisture Content Percent*	*Specific Gravity*[2]
		Bottom (Tensile) Lamination			
1	5,140	8,940	3,090	12.3	0.62
2	5,140	9,480	3,060	11.5	0.61
3	7,110	9,660	2,850	11.2	0.60
4	7,880	9,720	3,110	11.2	0.60
5	4,350	9,650	3,260	11.2	0.59
6	5,510	9,830	3,560	11.3	0.60
Average	5,860	9,550	3,160	11.4	0.60
		Top (Compressive) Lamination			
7	6,330	9,880	3,150	9.2	0.56
8	8,290	9,860	3,020	9.3	0.57
9	6,690	10,220	3,180	9.0	0.56
10	7,140	10,390	3,020	9.6	0.58
11	8,720	10,470	3,140	9.4	0.57
12	5,560	9,980	3,320	9.7	0.57
Average	7,120	10,130	3,140	9.4	0.57
		Basic Values[3]			
Average	5,850	7,430	----------	12.0	0.48

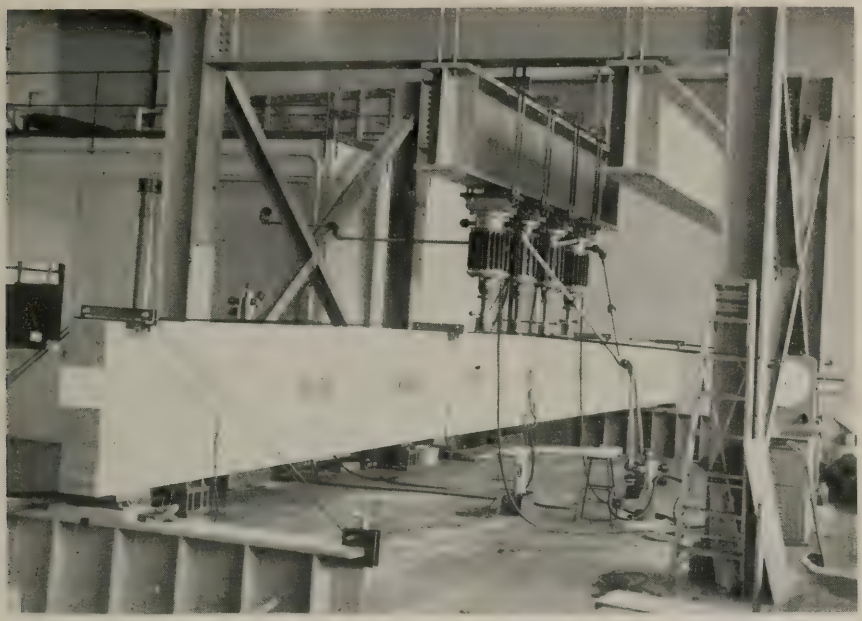
[1]Tested parallel to grain. Specimens taken from area near center of span.
[2]Computed on basis of volume at test and oven-dry weight.
[3]From Table 12 of Wood Handbook.



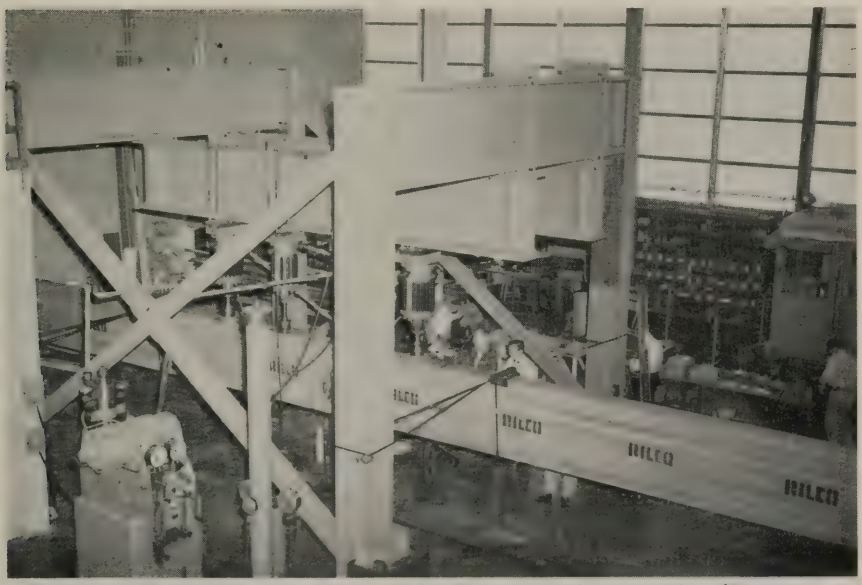
Photograph 1—View of electronic strain gage equipment used to determine tensile and compressive strains at center, shear strains at end and deflection at center of girder.



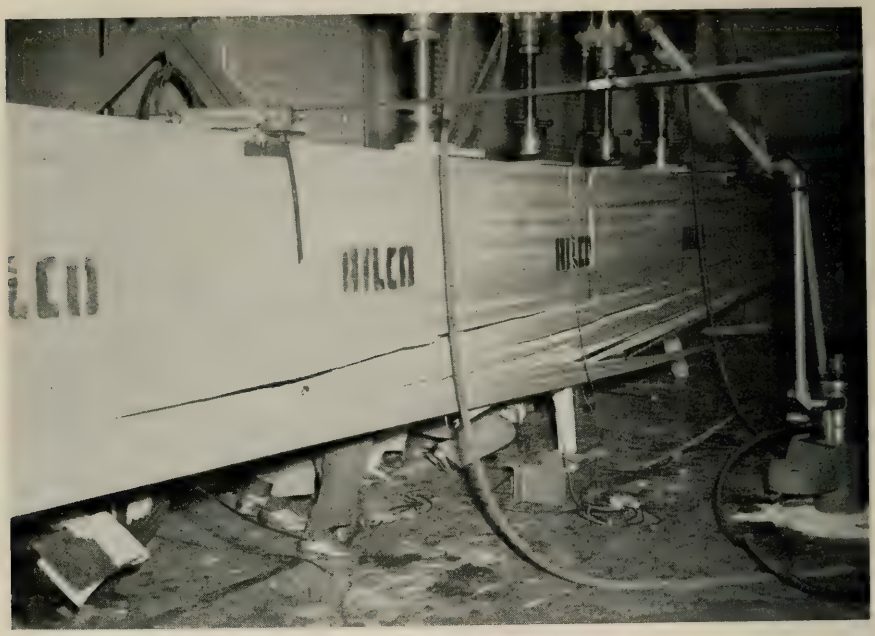
Photograph 2—Close view of girder showing large number of scarf joints near center of girder.



Photograph 3—General view of 52-ft laminated girder in loading frame. Static load was applied by hydraulic jacks. Oil pressure was supplied by pendulum dynamometer shown between columns.



Photograph 4—View of girder and pulsator used to supply oil pressure for 25-ton jacks. Pulsator is normally used for repeated-load tests.



Photographs 5 and 6—Views of girder after failure under load producing a calculated stress of 8150 psi.

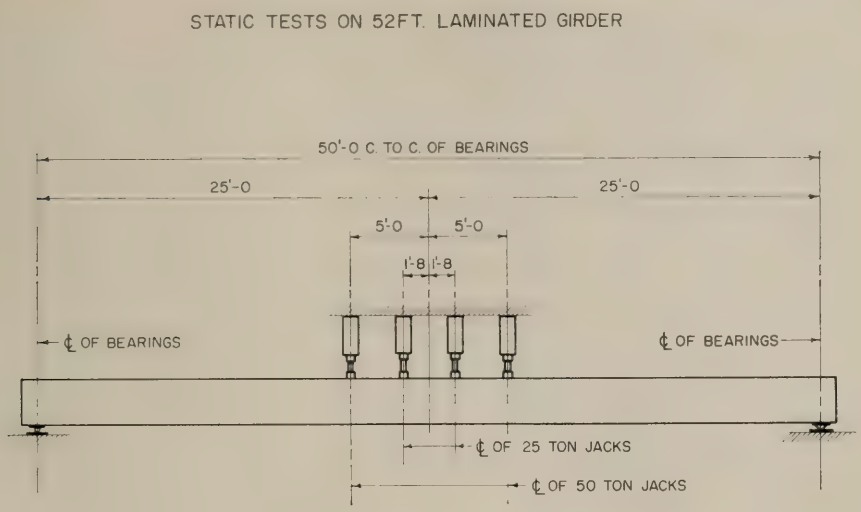

STATIC TESTS ON 52FT. LAMINATED GIRDER
50'-0 C. TO C. OF BEARINGS
25'-0
25'-0
5'-0
5'-0
1'-8
1'-8
℄ OF BEARINGS
℄ OF BEARINGS
℄ OF 25 TON JACKS
℄ OF 50 TON JACKS

Fig. 1.

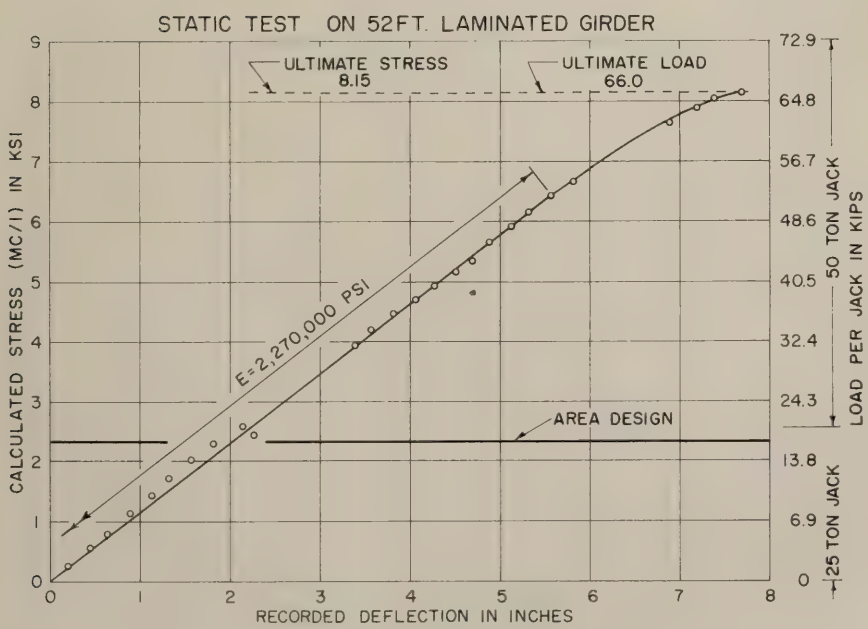

STATIC TEST ON 52FT. LAMINATED GIRDER
ULTIMATE STRESS
8.15
ULTIMATE LOAD
66.0
E=2,270,000 PSI
AREA DESIGN
CALCULATED STRESS (MC/I) IN KSI
RECORDED DEFLECTION IN INCHES
LOAD PER JACK IN KIPS
50 TON JACK
25 TON JACK
0
1
2
3
4
5
6
7
8
9
72.9
64.8
56.7
48.6
40.5
32.4
24.3
13.8
6.9
0

Fig. 2.

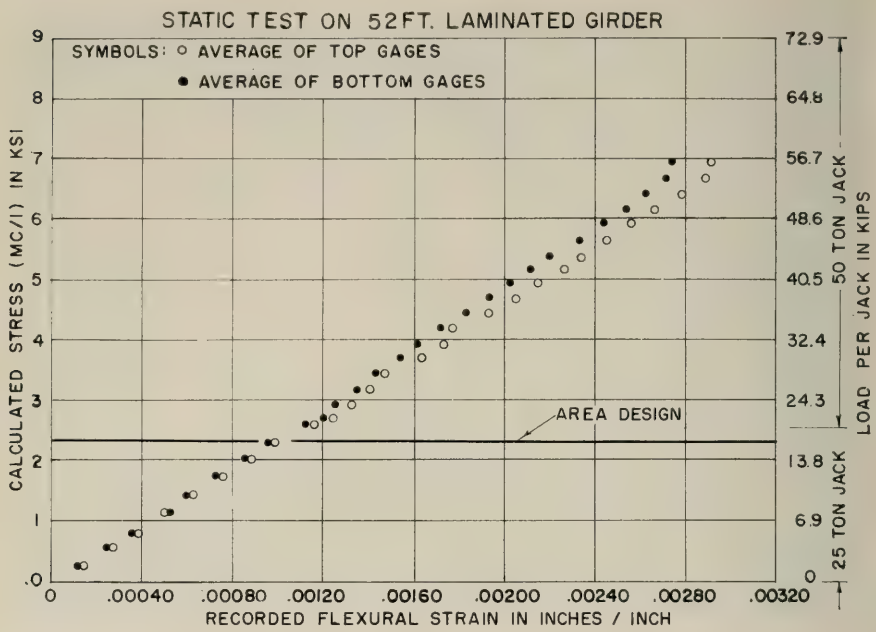

STATIC TEST ON 52FT. LAMINATED GIRDER
SYMBOLS: ○ AVERAGE OF TOP GAGES
● AVERAGE OF BOTTOM GAGES
CALCULATED STRESS (MC/I) IN KSI
9
8
7
6
5
4
3
2
1
.0
0
.00040
.00080
.00120
.00160
.00200
.00240
.00280
.00320
RECORDED FLEXURAL STRAIN IN INCHES / INCH
AREA DESIGN
72.9
64.8
56.7
48.6
40.5
32.4
24.3
13.8
6.9
0
50 TON JACK
25 TON JACK
LOAD PER JACK IN KIPS

Fig. 3.

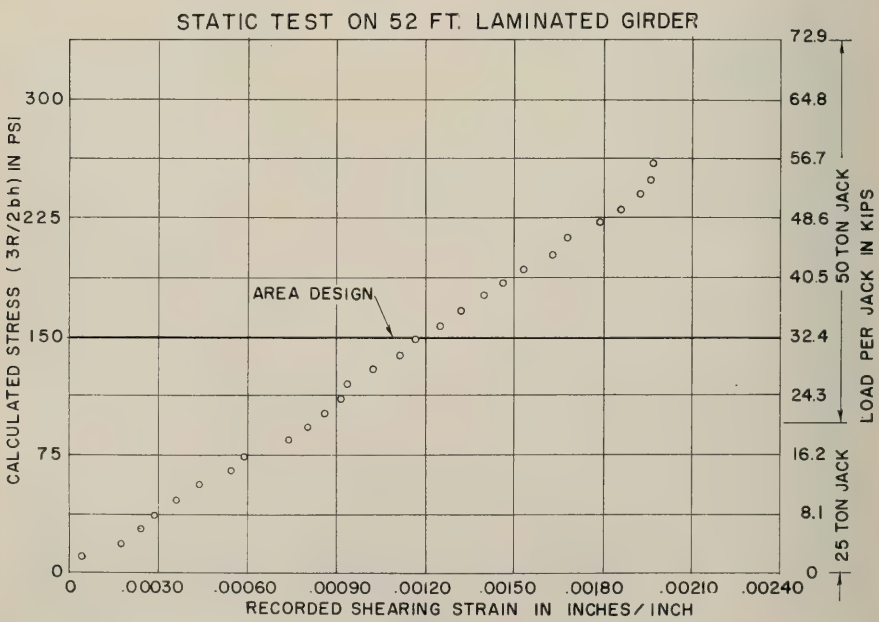

STATIC TEST ON 52 FT. LAMINATED GIRDER
CALCULATED STRESS (3R/2bh) IN PSI
300
225
150
75
0
0
.00030
.00060
.00090
.00120
.00150
.00180
.00210
.00240
RECORDED SHEARING STRAIN IN INCHES/INCH
AREA DESIGN
72.9
64.8
56.7
48.6
40.5
32.4
24.3
16.2
8.1
0
50 TON JACK
25 TON JACK
LOAD PER JACK IN KIPS

Fig. 4.

Report on Assignment 7

Repeated Loading of Timber Structures

C. V. Lund (chairman, subcommittee), W. L. Anderson, C. E. Atwater, A. W. Carlson, K. L. DeBlois, D. J. Engle, J. D. Fraser, W. A. Genereux, F. J. Hanrahan, J. F. Holmberg, J. V. Johnston, L. R. Kubacki, R. E. Kuehner, T. K. May, J. G. Shope, L. W. Wood.

At the request of this committee, the AAR Research Center undertook to determine the comparative strength of timber joints using bolts of various sizes under loading conditions simulating the ordinary connections of sway braces to piles in trestle construction. The specimens used were full size.

The results of this investigation appear in Bulletin 551 for June-July 1959 in a report titled "Static and Repeated-Load Strength of Bolted Timber Joints."

While this research was necessarily limited in scope, and the many variables characteristic of timber were not fully controlled, the conclusions reached are nevertheless worthy of careful study in the evaluation of the comparative strength of various sizes of bolts.

As a result of this investigation, AREA recommended designs currently call for the use of 1-in-diameter bolts, or as an alternate, the use of ¾-in-diameter bolts with spike grids, provided, however, that the grids are fully embedded into the timbers connected.

Report of Committee 24—Cooperative Relations with Universities

W. H. Huffman, *Chairman*

W. W. Hay, *Vice Chairman*
W. S. Kerr, *Secretary*

W. S. Autrey
George Baylor
R. H. Beeder
H. B. Christianson, Jr.
R. P. Davis (E)
J. F. Davison
G. H. Echols
E. I. Fiesenheiser
R. J. Fisher
R. T. Fortin
G. V. Guerin
R. R. Gunderson
C. E. R. Haight
W. E. Hiltebeitel
R. P. Howell
S. R. Hursh
H. E. Hurst
A. V. Johnston
Frank Kerekes
H. E. Kirby
T. R. Klingel
J. W. Laurent
E. C. Lawson
B. B. Lewis
H. S. Loeffler
R. E. Loomis
R. W. Middleton
G. W. Miller
R. C. Nissen
W. A. Oliver
J. F. Pearce
J. E. Perry
R. B. Rice
W. T. Rice
R. W. Ripley
V. J. Roggeveen
J. A. Rust
W. C. Sadler*
P. S. Settle, Jr.
H. O. Sharp
John Stang
R. J. Stone
D. W. Tilman
R. D. White
T. D. Wofford, Jr.
Committee

(E) Member Emeritus.
* Died October 14, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Stimulate greater appreciation on the part of railway managements of
   (a) the importance of bringing into the service selected graduates of colleges and universities, and
   (b) the necessity for providing adequate means for recruiting such graduates and of retaining them in the service by establishing suitable programs for training and advancement, and
   (c) the use of the best techniques and methods for recruiting college and university students, these to be set forth in a guide.

   A complete report was submitted last year on Item (c). The Student Recruitment Guide as prepared was distributed to chief engineering and maintenance officers by the executive secretary on April 7, 1959. Progress is being made on assignments (a) and (b) which will be further developed during the coming year.

2. Stimulate among college and university students a greater interest in the science of transportation and its importance in the national economic structure by
   (a) cooperating with and contributing to the activities of student organizations in colleges and universities, and
   (b) presenting to students and their counselors a positive approach to the attractive and interesting features of the railroad industry and the advantages of choosing railroading as a career.

Progress report on Assignment 2 (a), presented as information ..... page 613

3. The cooperative system of education, including summer employment in railway service.

Progress report, submitted as information ..... page 614

4. What constitutes a desirable curriculum for students to pursue in preparation for a career in railroad engineering?

Preliminary research indicates that the apparent trend in engineering curricula is an increase in mathematics, sciences and cultural courses, a decrease in engineering application courses, and an increase in graduate instruction. Future engineering graduates entering railroad engineering may require additional training in surveying, drafting, construction, and practical engineering. Study will be continued in 1960.

5. Consider the advisability of establishing student membership in the AREA.

Final report, submitted as information ..... page 615

6. Procedures for orienting and developing newly employed engineering personnel.

Progress report, submitted as information ..... page 616

7. Stimulate an interest by college and university staff members in current railroad problems and practices, including AREA membership.

Progress report, submitted as information ..... page 618

THE COMMITTEE ON COOPERATIVE RELATIONS WITH UNIVERSITIES,
W. H. HUFFMAN, *Chairman.*

AREA Bulletin 555, January 1960.

MEMOIR

Walter Clifford Sadler

Walter Clifford Sadler, professor emeritus of civil engineering, University of Michigan, passed away at Pacific Palisades, Calif., on October 14, 1959.

Professor Sadler was a native of Elgin, Ill., and received his civil engineering degree from the University of Illinois in 1913; his M.S. degree from Massachusetts Institute of Technology in 1921; his graduate Civil Engineering degree from the University of Illinois in 1927 and his law degree from the University of Michigan in 1930.

Professor Sadler had gone on retirement furlough on September 1, 1959, after serving at the University of Michigan since 1925. He was a veteran of both world wars, being awarded the Army Commendation Ribbon in World War II.

He joined the AREA in 1926, becoming a member of Committee 14—Yards and Terminals, in 1930 and of Committee 24—Cooperative Relations with Universities, in 1940, remaining on both these committees until his death.

He was extremely active in his chosen field, being the author of five textbooks, coauthor of one book and associate editor of another. Besides these activities, he was extremely interested in civic affairs, being mayor of Ann Arbor for two terms.

Professor Sadler gave generously of his time to committee work and enjoyed an excellent reputation for his broad experience and judgment. Members of Committee 24 sincerely regret his untimely passing and will miss their friendly and pleasant association with him.

Report on Assignment 2

Stimulate Among College and University Students a Greater Interest in the Science of Transportation and Its Importance in the National Economic Structure by (a) Cooperating with and Contributing to the Activities of Student Organizations in Colleges and Universities

B. B. Lewis (chairman, subcommittee), R. P. Davis, G. H. Echols, W. W. Hay, W. H. Huffman, T. R. Klingel, H. S. Loeffler, G. W. Miller, J. F. Pearce, R. B. Rice, W. T. Rice, J. A. Rust, P. S. Settle, Jr., H. O. Sharp, R. D. White.

The activities of your committee on this assignment are indicated by the following excerpts from letters of committee members:

H. B. Christianson, Jr., assistant to vice president—operations, Chicago, Rock Island & Pacific Railroad, presented a talk entitled "Chicago Terminal Consolidation" to civil engineering students at the University of Illinois.

R. P. Davis, dean emeritus, College of Engineering, West Virginia University, talked with many engineering students about the future open to engineering graduates in the railroad field.

J. F. Davison, assistant to system chief engineer, Canadian National Railways, indicated that representatives of his railroad had visited six Canadian universities during the year. Also, *Dr. O. M. Solandt, vice president—research and development, CNR,* gave two talks, one of which was before engineering student body of the University of Saskatchewan.

G. H. Echols, chief engineer, Southern Railway System, entertained engineering students at dinner on several occasions in an effort to bring them up to date on modern railroading. *J. F. Beaver, assistant chief engineer,* presented a program, including some films on mechanized operations, for the Junior Chapter of ASCE, George Washington University, Washington, D.C.

R. J. Fisher, engineer of bridges, Reading Company, interviewed and talked with civil engineering students on four separate occasions during the past year.

W. S. Kerr, vice president and business manager, Northwestern University, had many meetings with students groups and gave six speeches to outside clubs and organizations.

H. E. Kirby, cost engineer system, Chesapeake & Ohio Railway, "As chairman of the Education Subcommittee of the Railroad Community Committee of this area, which together with the Science Department of Marshall College, sponsors local science fairs at 21 area high schools in West Virginia, Kentucky and Ohio, I gave brief talks to the science students and faculties of many of those high schools. This program was climaxed by an area science fair held at Marshall College in early April at which some 600 student projects were exhibited.

"In addition, I had a little activity as chairman of the Tri-State Technical Societies Council, which comprises local chapters of national professional bodies, together with the Engineers Club of Huntington, West Virginia Academy of Science, etc. This group, acting with the science and mathematics coordinator of local schools, sponsored a seminar in which 16 of the more promising students participated. This fully voluntary project covered a period of seven weeks, meeting one evening each week."

B. B. Lewis, professor railway engineering, Purdue University, took the senior civil engineering class to Chicago, where they visited Markham Yard and observed its operation.

G. W. Miller, assistant general manager, Canadian Pacific Railway, conducted a group of 40 high school principals and teachers on a tour of railway facilities in Toronto.

John E. Perry, professor, civil engineering, emeritus, Cornell University, advised that *C. J. Henry, chief engineer, Pennsylvania Railroad,* spoke at the annual meeting of the Ithaca section of the ASCE at Cornell, and members of the student chapter were the invited guests.

V. J. Roggeveen, assistant professor of transportation engineering, Massachusetts Institute of Technology, arranged the following programs concerned with railroads:

An inspection trip to the Boston & Maine Railroad to see its CTC control machines, tour its service building for Budd Railcars, look at LCL freight handling facilities, inspect yard and track layouts, and talk to its engineer maintenance of way.

"Transportation Seminar" by *R. B. Hasselman, Boston and Albany Division, New York Central System,* followed by a one-hour discussion.

The following movies and slides were shown:

Movie on Flexivan
"Trouble at Troublesome"
"The Big Train"
AREA slides on railway engineering and maintenance.

Several AAR publications were distributed to classes.

R. J. Stone, vice president operations, St. Louis-San Francisco Railway, made presentations to senior students studying business policies at Washington University in St. Louis regarding the objectives, policies and problems of the railroad industry.

During the fall and spring of each year, five members of the Frisco engineering department interview senior engineering students in 20 midwest colleges and universities, explaining what the engineer can expect in the railroad field.

T. D. Wofford, Jr., engineer of design, Illinois Central Railroad, presented a film entitled "Four Major Projects Handled by the Engineering Department", with appropriate comments, to the Student Chapter, ASCE, at Mississippi State University.

During 1959, the slide sets developed by Committee 24 depicting railway construction and maintenance operations were loaned to various railroads and schools a total of nine times.

Report on Assignment 3

The Cooperative System of Education, Including Summer Employment in Railway Service

W. A. Oliver (chairman, subcommittee), G. Baylor, E. I. Fiesenheiser, R. T. Fortin, G. V. Guerin, W. W. Hay, W. H. Huffman, J. W. Laurent, R. C. Nissen, R. B. Rice, R. J Stone, T. D. Wofford.

This is the second consecutive year that the committee has canvassed the Class I Railroads of the United States and Canada regarding opportunities for summer employment for college students. As a result of this canvass, 12 railroads stated that they would employ a total of 65 students in various classes of engineering and maintenance department work, stated salaries offered, and the names of those to whom applications should be made. This information was subsequently sent to the deans of engineering of more than 125 colleges in the United States and Canada.

However, the number of students to whom offers were made as a result of the committee's questionnaire was only a small fraction of the total number employed by the railroads during the 1959 summer vacation period. A number of railroads, including some of the larger ones which regularly employ a considerable number of students for summer work, did not report their requirements, pointing out that they regularly conduct their own student recruiting at the colleges along their lines. The importance of this direct recruiting as far as numbers involved is concerned is emphasized when it is known that two railroads have reported a total of 488 college student employees on their payrolls during the past summer. These were not all engineering students by any means, and they were employed in many capacities, but the point of importance is that a large number of college students were given employment.

Summer employment of college students has advantages for both the student and the railroad. The student is enabled to earn money to make possible the continuance of his education and he, also, obtains firsthand knowledge of railroad work. The railroad has the opportunity to observe and consider the student as a possible permanent employee and, also, to interest him in railroading as a career. And, in any event, it is a means of improving public relations.

Committee 24 has been commended by both the railroads and the colleges for this activity and plans to continue the project during 1960.

Report on Assignment 5

Consider the Advisability of Establishing Student Membership in the AREA

John Stang (chairman, subcommittee), W. S. Autrey, R. H. Beeder, R. J. Fisher, R. R. Gunderson, W. W. Hay, W. H. Huffman, S. R. Hursh, A. V. Johnston, R. C. Nissen, J. E. Perry, W. C. Sadler, R. J. Stone.

This is a final report, submitted as information.

To begin this assignment a questionnaire was sent to all members of Committee 24 requesting information as to the advantages, disadvantages, qualifications, annual dues, rights of student members, and other associated items.

The answers received from this questionnaire were analyzed, and it was the consensus that having a student membership classification would result in a definite advantage to the railroads, as well as an advantage to the students concerned.

The AREA Constitution would have to be amended to include an additional class of membership, namely, "Student Member", adding to the five classes of membership now listed under Article II (1). The general qualifications listed under Article II (2) (A) would also be amended and a definition of a Student Member would be added directly after the qualifications for a "Junior Member".

It is recommended that the Student Member qualifications be as follows:

G. Student Member

(a) A Student Member shall be enrolled in the negineering school of an accredited engineering college or university, and be in good academic standing.

(b) His membership in this classification in the Association shall terminate upon graduation or upon discontinuing his enrollment as described in (a) above.

(c) He may make application for membership other than as a Student Member at any time when he becomes eligible to do so.

It is recommended that no entrance fees be required for student membership and that annual dues be held to a minimum, with a suggested cost of $2.50. Student members

should receive copies of the AREA bulletins and other miscellaneous publications, such as the AREA News, but not the Proceedings.

It is not intended that a definite program on a national basis be established for student members, but handled on a local basis, and conceivably in conjunction with the student chapters of ASCE. Short field trips could be arranged by contacting engineering representatives of local railroads and also have AREA members visit the campus to give short talks or speeches illustrated with the construction and maintenance slides previously developed by Committee 24. It is realized that considerable promotional work would be required by Committee 24, but it is believed that the mechanics could be developed very readily in conjunction with present Assignment 2, and would be further considered if favorable action is taken on this class of membership by the AREA Board of Direction.

Summarizing, the committee believes student membership in the AREA should be established and recommends to the Board of Direction that necessary action be commenced to amend the Constitution accordingly.

Report on Assignment 6

Procedures for Orienting and Developing Newly Employed Engineering Personnel

R. E. Loomis (chairman, subcommittee), H. B. Christianson, Jr., C. E. R. Haight, W. W. Hay, W. H. Huffman, J. W. Laurent, E. C. Lawson, R. W. Middleton, D. W. Tilman, R. D. White.

This is a progress report, presented as information.

The assigned topic has been of interest to the management officers of railroad engineering departments for many years. The "why" of training programs has been handled effectively under Assignment 1, so the work under this assignment will be concentrated on the "How" aspects of the subject.

Your committee started its examination of this field by attempting to determine the types of training programs currently in effect on the American railroads. This was done through the use of a questionnaire submitted to the chief engineering officers of 118 railroads. To date, about 50 of those carriers have responded, providing the basis for this report. A preliminary review of these answers follows.

The reports received from the various roads indicate that about 50 percent of them have an organized method of orienting and developing their newly employed engineering personnel. Of this 50 percent, one-half (12 roads) describe their program as formal; the balance are categorized as informal. Whether formal or informal, the programs can also be divided between those which confine their training to the maintenance of way department (considered to include both maintenance and engineering) and those which include experience and training in all major departments of the railroad. The majority of programs falling in this latter category concentrate upon training in engineering and maintenance of way, but also include time spent in transportation, accounting, telegraph and signals, motive power and equipment, and personnel. Thirteen railroads reported that their programs were confined to training engineers for the maintenance of way department. These railroads indicated that on occasion a graduate of their training program eventually transferred to another department; however, most roads considered such occasions to be rarities. Eight railroads reported that their programs were designed to include training and experience in several major departments.

In addition to the foregoing, 4 railroads reported that their programs were designed for the training of men who have shown the necessary potential during their first 6 or 12 months of employment. Another road stated that while its program is normally confined to engineering training, outstanding trainees also include operations in their training.

A third distinction can be drawn between the programs reported by comparing the duration of time spent in training. The time element involved varied from 9 weeks in one case to 4 years in another. In regard to these figures it should be noted that the road having the 9-week program employs a total of less than 1500 people. The carrier with the 4-year program employs in excess of 100,000 people. The desired end result of these two roads, of course, differs greatly. The small road described its program as an ". . . orientation course in the overall operation of the railroad." Its aim was to help the man in doing his own job by letting him become more conversant with the procedures, routes and general conditions in other departments of the railroad. The large road has a much different purpose in carrying out its program. Since it hires from 28 to 32 new engineers each year, it needs a systematic method of preparng its new engineering talent for the responsibilities they will face in the future. The majority of the programs was designed for a duration of two years. In some instances, the duration is flexible; the more potential the trainee shows, the longer is the program, thus giving the man a full opportunity to broaden his experience.

The scope of a training program is generally influenced by the promotional policy of the company involved. Where, as on several carriers, the engineer is looked upon as a potential senior officer, induction and development point up the avenues of advancement, and they explore the trainee's qualifications by means of training assignments. However, when the other extreme is present, it is not surprising to receive a comment such as the following:

". . . engineers are kept in strictly engineering functions. Technical people generally are not welcome on railroads . . ."

The comment most frequently reported via our questionnaire was that the reporting road (or its engineering department) was not large enough to justify a formal training program. This comment, or inferences amounting to the same, was received from roads employing up to almost 10,000 people. Three roads that each employ in excess of 20,000 people report that they have no program at all. On the other hand, three carriers that each employ less than 3,000 people do have specific plans established for training their new engineers. In addition, six other roads, each with less than 7,000 employees, have what they consider informal plans for training these men. In many instances their plan is a simple method of job rotation. In others, a detailed course of on-the-job study and experience is laid out to assure the trainee and the company that the trainee has had first-hand experience in each phase of work covered by the program.

Many of the smaller railroads expressed the feeling that formal training was something that could only be afforded by large railroads that have the facilities and the need to set aside a group of personnel akin to a staff of instructors. No such program was found on an American railroad, however. The basic idea that is apparent in all of the programs reviewed is to let the trainee get down to the grass roots of the work in the department and learn by doing. His instructors are the experienced supervisors, general foremen and division engineers. The "program" as such, is, in most instances, simply a scheduling of when and where the trainee is going to gain such experience. This thought is, perhaps, best expressed in the words of one chief engineer of a railroad that is by no means small:

"I do not feel that the procedure for developing and orienting engineers is a function

of the size of the railroad, since in most cases responsibility and authority is delegated to territories of approximately equal size regardless of the overall size of the railway system and, therefore, suitable guidance of an engineer in training is available regardless of the size as a whole."

As further study is given to this subject, this point will be kept in mind. It is the hope of this committee that the time and effort dedicated to this assignment will result in benefits to all railroads, regardless of their size.

The factor that has been the most outstanding in the brief study given to this subject to date is that a training program must be designed to accomplish just exactly what the company wants to get out of it. A 9-week program can be a great success when it is designed to speed up the trainee's overall familiarity with the railroad or engineering department. A more detailed program can be expected to do more, and it will when given the necessary forethought, study and planning as well as day-to-day effort to make it work. What we should want and expect from a good training program was very ably summarized by Chief Engineer Frank R. Woolford of the Western Pacific Railroad, who said:

"If we are to gather and *keep* young college engineers, we must realize what each one is trying to achieve in society. I believe these are as follows:

a. He wants to do professional work.
b. He wants an opportunity for promotion as a professional employee.
c. He wants financial incentives as a reward for his increasing contributions to his company.
d. His job must be supervised from a professional viewpoint.
e. He wants, and must have, professional recognition within the enterprise and the community as a whole.

"I place our engineering profession on the same level as any other profession and firmly believe graduate, qualified and well trained engineers should be placed on the same plane as other professional groups and given equal, if not above-the-average, monetary compensation for their efforts and know-how in the improvement of the world in which we live. I feel if we (management) keep these things in mind in orienting and developing newly employed engineering personnel, we cannot help but succeed in making our engineering family a happy and successful one—a duty with which we are certainly charged."

This report will be further persued during the coming year.

Report on Assignment 7

Stimulate an Interest by College and University Staff Members in Current Railroad Problems and Practices, Including AREA Membership

W. W. Hay (chairman, subcommittee), R. H. Beeder, R. P. Davis, R. J. Fisher, G. V. Guerin, W. E. Hiltebeitel, R. P. Howell, W. H. Huffman, W. S. Kerr, J. E. Perry, V. J. Roggeveen.

Your committee submits the following report of progress as information, covering two phases of this assignment.

Part 1

The first phase involved the mailing of a questionnaire to the deans of 125 accredited engineering schools and colleges to determine the attitudes of college faculties toward the railroad industry, railroad engineering, and the AREA. Only on this basis, it was felt, could an informed solution to the problem be developed.

Replies were received from 73 engineering schools and colleges, which is 58.4 percent of those solicited—a more than representative sample. Most of the questionnaires were carefully completed, contained many explanatory and supporting comments, and, in a few cases, were further amplified by letters. Among those answering the questionnaires were 27 deans of engineering, 23 heads of civil engineering dpartments, 5 professors, 6 associate professors, and 2 assistant professors of civil engineering, and 10 miscellaneous, including one college executive secretary, 3 assistant and associate deans, and one mechanical engineering department head.

The following summation gives the questions, answers, and comments from the questionnaire replies.

1. *Indicate what importance you attach to railroads as a part of the United States transportation system; check one. Most important*—29; *important but no more so than other elements*—44; *minor importance*—0.

Railroads are considered an important element in the transportation system in 100 percent of the replies (but most important in only 40 percent). No replies rated railroads as of minor importance. Comments spoke of railroads as "all-weather transportation", as "minor for passenger service" and as "necessary to the welfare of the country." The comments also mentioned the "wartime importance of air transport" and the "need to consider all parts of the transportation system."

2. *Do you regularly encounter articles on various phases of railroad research, design, consrtuction, and maintenance in your technical reading?*

Of the 71 replies to this question (two didn't answer it), 33 said they did, 38 said they didn't. Of those who said they did 6 qualified their reply by saying "only to a limited extent", and 4 said they were close to railroad literature, reducing the "yeses" to 23 and increasing the "nos" to 48. Among those who didn't encounter many articles, two blamed it on insufficient railroad research activity and another said he found mostly articles on highways.

These answers indicate that railroads are not obtaining a proportionate amount of space in technical and professional publications outside the railroads' own field.

3. *In your opinion are college staff members sufficiently acquainted with railroad problems so they can and do use these problems to illustrate the engineering principles they are teaching?*

Twenty-five answered "yes", 45 said "no". Two "yes" answers were qualified by "to a limited degree" and "only by those who teach it". Among those who said "no", two said it varies among individual teachers, and another said it was because too few graduates go to railroads. Evidently railroads do not receive much classroom mention.

The second part of this question read: *If "no", do you feel they should be?* To this, 30 answered "yes", 11 said "no", and 6 didn't know or didn't answer. Among the comments offered, 3 thought mention should be made only to a minor degree and only as regards basic theory. Another said most staff members would have no knowledge of or interest in railroads. Another thought mention should be made only by those teaching railroads, and one other said there was no need to mention railroads.

4. *As a university or college (staff) member advising a student, would you recommend that he take a position in the railroad industry?*

Here 47 said "yes", 14 said "no", and 2 said "yes and no"—depending upon the student.

Among those saying "yes", 14 said they would so advise only if the student was already interested in the field; 21 based their "yes" on the good opportunities in railroad engineering; 2 criticized the railroads as "unprogressive"; 1 said the railroad industry was "OK for students of average ability."

Of those who said "no", 8 indicated they never recommend any specific industry but leave that up to the student. Several others were critical of the railroads and the opportunities or lack of opportunity offered. Three merely stated "no opportunity", two mentioned seniority as an undesirable feature of railroad employment, four said railroad management is not interested in hiring engineers or in their professional and scientific training. Three mentioned "unattractive careers" in a "conservative" industry with no "creative work." One reply said "engineers are the first to go in a depression", and another said he didn't "know enough about railroads to advise a student."

Preponderant opinion seems to be that railroads offer desirable careers only to those who are already interested in that line of work but that it isn't the sort of career or professional atmosphere to be recommended to most engineering graduates.

5. *Would you advise a college student to take one or more courses in railroad engineering?*

Twenty-eight said they would advise a course in railroad engineering; 42 said they wouldn't. Of the 28 "yeses", 5 qualified this by saying they would so advise only if the student is interested in going into railroad work and 3 others said they would advise it only as a part of a course in general transportation. Ten thought a course in railroad engineering afforded good engineering training and good background material, broadened outlook, and offered information on a subject about which all engineers should be informed.

Those saying they would not advise such a course included 20 who said it was too specialized, 6 who said there was no such course in their school's curricula, and others who said it is not "necessary"; that there are "no modern or exciting problems in railroad engineering and no progress"; that railroad engineering is of "minor importance"; and that "too few students enter the field to make it worth while." Nine replies said the student should be given a course in general transportation engineering rather than any specialized branch.

These opinions reflect in part the many demands of curricula on a limited amount of time. It appears that unless a five-year curriculum is adopted, almost all applied engineering will give way to basic courses in fundamentals, leaving the applications to postgraduate years or to training courses within each industry. It is also evident that lack of interest in courses in railroad engineering will bring about even less interest in the field. The student cannot be expected to develop an interest in a branch of engineering about which he hears nothing during his undergraduate years.

6. *Do you consider railroads to offer attractive job opportunities in engineering?* Yes—44; No—24; Don't know—5.

The reasons given for considering that the railroads offer good job opportunities included opportunities due to few engineers entering the field and the retirements of older men (3), the need for engineering in railroad work (2), good training programs (2), early acquiring of responsibility (2), knowledge of satisfied graduates who have entered this field (2).

Among the reasons why railroad engineering was not thought to offer good job opportunities, the routine nature and lack of challenge of the work were listed by 4,

lack of railroad interest in engineers by 2, seniority and slow advancement by 4, backwardness in research and improvement by 1, declining business and "best jobs are all in management" by 1, and "I hear from disgusted students who have quit" by 1.

Evidently a majority of college staff members see railroads as offering good careers, but there is also a large segment that sees in railroad engineering little opportunity and views the work as dull, routine, and without challenge. These views correspond closely to the views expressed in the somewhat similar Question 4.

7. *Do you consider non-engineering positions on a railroad as offering attractive job and career opportunities for engineers?* Yes—29; No—25; Don't know—19.

The "yeses" and "nos" on this question were about evenly divided with a large area of uncertainty. Administrative and managerial positions were listed by 15 as offering good opportunities. One reply said an engineer is well trained for any job. Two replies specified operations as good and one specifically said "not in operations."

The 25 who said "no" stressed the need for engineers in engineering work (3), preference for engineering work by engineering graduates (2), lack of railroad interest in engineers (1), and declining railroad business (1). The others gave their answers without comment.

There seemed little awareness here of the great variety of work being performed by engineers on the railroads, including non-engineering tasks.

8. *How would you rate railroad engineering as a career in comparison with other major industries (using the terms excellent, average, poor, undesirable, as regards a. remuneration, b. advancement, c. living conditions?)*

The replies are here tabulated.

Rating	(*a*) *Remuneration*	(*b*) *Advancement*	(*c*) *Living Conditions*
Excellent	5	8	1
Average	45	31	29
Poor	12	24	22
Undesirable	1	1	
Don't know	10	8	20

Only two comments accompanied these ratings: "These matters aren't important; use of engineering skills is more important", and "These matters are subjective—depends on the individual."

The weight of opinion appears to lie between "average" and "poor", 105 using "average" and 58 rating "poor." It would seem that pay, advancement, and living conditions are not attractive features of railroad careers. This is a good thing if men are thereby eliminated who are concerned only with these factors. It is a bad thing if it discourages men who can find elsewhere an interesting and challenging job *plus* excellent pay, advancement, and living conditions. One can also conclude, however, that (a) and (c) at least are not likely to be deciding factors in a choice between two industries.

9. *Is there a lack of interest in railroad careers among college and university students?* Yes—62; No—3; Don't know (or didn't answer)—8.

The comments on this question reflect the critical attitudes of the preceding replies. Eleven replies listed lack of opportunity in a "dying industry", 8 listed "lack of glamor". "Backwardness" of the railroads received 3 mentions. Lack of railroad interest in students was mentioned 7 times; poor pay, advancement, and social life 7 times. A lack of information and failure of the railroads to recruit or visit universities received 11 mentions;

lack of technical progress and research by the railroads 3; dull routine work with no challenge 4; rules and seniority 3; poor public relations 2; and limited opportunities—1.

The following reasons were also given: "Stay away from an industry being beaten by its competitors", "No teacher ever mentions it", "De-emphasis in curriculum", "No professional status", "No literature on carreers", "Too much emphasis on highways", and "This is a poor question—students give no special consideration to any industry."

There is little doubt from the answers and comments to this question that students generally do not consider railroads to offer good career opportunities and that they look on railroads as having little future and offering only unattractive, routine opportunities. The comments also indicate a wide divergence of opinion about railroads, some of it plainly contrary to the facts (although possibly true as regards some individual schools and railroads). Regardless of the truth of the statements, these must be recognized as representing a considerable volume of student opinion.

10. *In your opinion, are university and college staffs normally familiar enough with railroad engineering work and opportunities to advise graduates concerning railroad employment? If you answer "No" and you feel they should be, what could be done to keep them better informed?* The answers were: Yes—21; No—51; No answer—1.

The comments (in substance) and the number of replies advancing these thoughts are here tabulated.

Offer summer employment and consulting work to college staff members	10
Provide railroad technical literature to college staffs on railroad problems and accomplishments	10
Develop better recruiting programs by personal contact with faculties, providing literature giving job descriptions, opportunities, and advancement of recent college graduates and executives	9
Hold faculty—management seminars to explain problems, needs and accomplishments	6
Develop on-campus research programs	6
Prove a demand for engineering graduates by hiring	3
Give on-campus lectures	1
Encourage AREA membership among university staff	1

Other comments included:

"They (the students) just aren't interested."
"Railroads are not an area of interest."
"A pamphlet would help."
"Best reference is satisfied alumni."
"Clean house internally."
"Railroad option out—lack of interest."
"Don't know"—6 so stated.

The answers and comments to this question, coupled with those of the preceding question, plainly indicate that the railroads face a difficult problem in selling themselves to the students and can expect little informed help from the staffs. Many of the suggestions offered above have been carried out by the railroads for many years, at least on some campuses.

11. *How do you compare railroads with other industries in their furthering and exploiting research? Check those which apply.*

The following replies were given.

a. Excellent	4
b. Adequate	12
c. Insufficient	40

d. Lack of railroad research has caused loss of prestige and interest 41
e. Presence of railroad research has held prestige and interest 5
f. Research is not a factor 3
Don't know 7

Only a few comments accompanied this question:

"Railroad research has been inadequate for too many years."
"Should not have to belong to the AREA to find out about research."
"Adequate only in recent years."
"Railroad research is non-existent in the Northwest."

From the above figures, over half the replies (55 percent) consider railroad research to be inadequate. The actual number listing it as inadequate is greater than this because not every reply checking d also checked e and vice versa. There were 51 replies or 70 percent that checked c or d or both. Research has become a big factor in the life of most universities, and failure to keep pace with the activities of other industries in this field is bound to have unfavorable repercussions.

12. *Are you acquainted with the work and purposes of the American Railway Engineering Association?* Yes—60; No—12; No answer—1. *To what extent?* To this part of the questions, answers in substance were the following:

Through reading AREA publications 10
Slightly (method not defined) 10
Moderately 9
An AREA member on committees 8
Through AREA Bridge Specifications 7
University sponsors one membership 1
Through staff member who is in AREA 1
Works in projects of interest to railroads 1
Worked on railroads 1

These answers, although not representing a numerically large group, indicate there can be considerable interest value in AREA membership and publications.

This question had also a second part: *If "No", would you like to be informed?*

Twenty-two replies made specific answer to this question, 21 saying "yes" and 1 saying "no." Comments in this connection included:

"Would like additional literature to know more about it."
"Yes, if something good can come of it."
"Yes; but not much needed by deans."

A conclusion to be drawn from this question is that the AREA offers a promising medium through which to arouse faculty interest in railroad engineering.

13. *What specific acts or policies could the railroads adopt to impress their status with you and in the eyes of your colleagues?*

A substantial list of suggestions and comments were received and are here summarized. As in previous questions, the numbers in parentheses tell the number of times this factor was mentioned.

Sponsor research, including the operational area; assume more leadership in research and design (12).

Maintain communication with faculty and staff on the campuses by personal visits to campuses, roundtable discussions and seminars and inspection trips on railroad property, and full discussions of the needs and problems of railroad and college (12).

Publicize technical improvements, forward thinking, and progress of the railroads (6).

Carry on a more active recruiting program by publicizing job opportunities for graduates and undergraduates, visits to campuses by young, successful graduates in railroad employ (5).

Improve the technical performance of the railroads; be more progressive; modernize methods and equipment (4).

Provide summer employment for students and staff (3).

Prove an interest in college graduates by making railroad careers worthwhile and employing more students (6).

Work directly with colleges to guide and support educational programs (2).

Fight for what is rightfully yours; resist government encroachment; go after the passenger business (3).

Improve public relations; tell magnitude of rail transport; educate public to realize railroads aren't doomed (3).

Each of the following was mentioned once.

"Stop publicity against competitors; stress railroad advantages and improve those."

"Direct career activities toward high school students."

"Provide list of research problems."

"Make use of the cooperative system of education."

"Provide descriptive literature."

"Provide better salaries for engineers."

"Don't fire employees just before it is time for them to take their pensions."

"Railroad top officers should participate more in community and university affairs."

"Request the National Research Council for a research study."

"Provide campus speakers."

"Advance cause of engineering education to public."

"Invite research on railroad management from the management engineer's viewpoint."

"More short trains."

"Distribute Proceedings to faculty members."

"Get university staff members into AREA committee work."

"A difficult problem; railroad construction and design are minor compared to highways."

"Improve railroad financial position."

"Show welcome to customers."

"Discard crying towel."

"Discard up-from-ranks promotion."

"Employ more scientific and technical personnel."

"Provide passenger service."

"Avoid railroad hostility to general public."

"Make clear to young men his abilities won't be obsrtucted by labor practices or unimaginative management."

"Be more consistent and considerate in contacts with college staffs."

"Revolutionize plant and rolling stock to appeal to traveling public."

"More speed."

The foregoing have been included in considerable detail to indicate the nature of the thinking, criticism, and complaints among college and university staffs regarding railroads; also to present a number of worthwhile suggestions.

14. *What cooperation do you believe desirable between* a. *Industry in general and universities?* b. *Railroads and universities?*

In analyzing these answers, no attempt has been made to distinguish between answers to a and b. Except where obvious reference is made to railroads, the same answers applied to both railroads and industry in general. Most replies were worded to that end. These answers are presented in the same way as for question 13.

Keep university staffs advised of progress, problems, and needs of the railroads and learn the same for the universities through roundtable discussions, exchange of ideas, personal contact, and technical literature (18).

Sponsor university research, including applied and cooperative research (15).

Provide summer work for students and staff members (consulting work for older staff members); university staff members should spend more time in industry (15).

Establish university scholarships and fellowships (15).

Tell universities what the railroads and industry expect of graduates, especially with regard to current developments and changes in industry (5).

Make speakers and industrial movies available (5).

Make financial grants (5).

Furnish demonstration and laboratory equipment to aid study and research (4).

Conduct more active recruiting, offering good jobs and good salaries to college-trained men (3).

Place college staffs on mailing lists of technical literature and send them accounts of research and development (2).

Advise the university of the progress of its students who have been employed (2).

The following comments and suggestions were made only once.

"Establish internships in industry."
"Stress role of railroads in over-all transport."
"Emphasize that railroads have a future."
"Get university staff in AREA committee work."
"Hire students with advanced degrees."
"There are no railroad representatives presently on industry-college committees."
"Railroads fail to participate in Research Council activities."
"Railroads must desire good relations with universities."
"Railroads should give the same personal service as the airlines."

DISCUSSION

Obviously some of the answers to questions 13 and 14 reflect a very personal reaction to the railroads on the part of those answering. Other replies indicate railroad efforts in the suggested areas have not been sufficiently widespread, far-reaching, or publicized. In spite of this, it is a fact that this committee has publicized a list of railroad films; has published and distributed to the colleges a recruiting brochure; publishes lists of available summer jobs for students; and has produced for loan to the colleges four different comprehensive sets of color slides of modern railroad construction and maintenance practices. Also, it is a fact that many railroads conduct well-organized recruiting campaigns, have good training courses, and are eager to employ college graduates.

Many of the comments and suggestions have considerable merit. Although much of the suggested cooperation, etc., has been tried by some railroads at some schools, these

replies indicate there are many schools which have not had close association with any railroad. It is also evident that there is considerable misunderstanding, confusion and lack of knowledge on the part of many university staff members regarding the railroads' interest in education, in research, and in the hiring of and providing suitable careers for trained engineers. Probably the railroads are not always aware of the reactions of college personnel.

Your committee has not yet developed suggested methods or programs for implementing many of these proposals. The comments, alone, may be suggestive enough in many instances. Of the many suggestions made, those which tend to enlighten and to dispel misunderstanding—to establish communications between universities and the railroad industry—are likely to be the most productive.

Enlarging on one group of suggestions, a series of conferences might be arranged between railroads and universities at which roundtable discussions and seminars could be held for full discussion of railroad and university needs and developments, curricula and job requirements, and other matters. These could be held at universities in the winter so that railroad personnel could see education and research in action. Summer conferences held on railroad property would enable the railroads to point out specific technical problems and to show off their plant and modern improvements.

Another area receiving much questionnaire comment is that of research. Question 11 gives further evidence of the importance attached to activity or lack of activity in this field. Railroads can cooperate here in many ways. The simplest, and one that can bring big rewards, is to keep staffs and students aware of problems which require solution. (Part 2 of this report will show steps your committee is taking in this direction.) Railroads can aid the research for Master and Doctoral theses by admitting students to their properties and giving them access to such information and records as is deemed suitable. Financial aid can be extended in the form of outright grants, establishing post-graduate research fellowships, donating equipment for study and laboratory use, sponsoring research, including that of an operational character, and participating in joint research with the National Research Council and other coordinated efforts. Not all research funds need come from the AAR research budget. Small sums made available to a number of schools to aid post-graduate students in their research could well be charged to advertising and public relations.

Staff members are also keenly alive to the type of recruiting carried on and the jobs and careers available to their students. Committee 24 has made numerous suggestions on this matter in past years and recently completed a recruiting guide and a general brochure. Use should be made of these aids.

Summer employment (and consultation) has received mention. Such arrangements can be highly beneficial to staff member and railroad alike. When so employed, staff members should be placed where they can obtain a favorable picture of railroad engineering and the progressiveness of the entire industry.

SUMMARY AND CONCLUSIONS

The following conclusions summarize the findings of the questionnaire answers and the explanatory remarks which accompanied most of these answers.

1. Although railroads are still considered an important part of the national transportation system by all (but not the most important part by most), a considerable number of college staff members, especially among the larger, better known schools, look on the railroads as an unglamorous, backward or static and dying industry, taking no

part in research or educational development and offering no suitable careers in which trained engineering graduates can use their scientific training. Evidently the public picture railroads have painted of themselves as a suffering industry has been absorbed by the public. Most staff members feel that pay, advancement, and living conditions are not good.

2. The many recent additions to scientific knowledge have required a concentration on fundamentals by the student as contrasted to applications of those principles.

3. This state of affairs is aggravated by the emphasis on other engineering areas, especially highways in the case of civil engineers, the elimination of courses in and reference to railroads and railroad engineering from the curricula, and the interest in graduate study and research in which many universities, apparently, find little railroad on-campus interest or activity.

4. There is also a feeling that railroad engineering is cut and dried, routine, and without problems or challenge, and that engineering training is wasted on railroads at a time when engineers are in short supply elsewhere. There is also a feeling that railroad management is unsympathetic to college-trained engineers and that their ability and ideas are thereby ignored as well as being held back by union rules and seniority. This is a view which the staff members believe is widespread among the students as well.

5. These are serious charges, to the extent that they are true, of the industry or of any one railroad. The principal problem is, however, not these individual charges but an apparent general breakdown in communication between railroads and universities and their engineering faculties. Any effort to correct these views must begin by an improvement in that communication.

6. The AREA is best known through its publications, especially its bridge specifications. Staff members would generally like to know more about it, about its work, and to participate therein. The AREA affords an excellent way to establish and retain contact with college staffs. Although many comments and suggestions are offered in the questionnaire replies, a few stand out as being given more frequent emphasis and mention, and also as being fundamental in character and aimed at the re-establishment of communication.

a. Arrange conferences, seminars, and inspection trips between selected railroad and university personnel to inform each other of their problems, needs, plans, accomplishments.

b. Railroads should display and take a more direct interest in university research. This should include research on operations problems which are peculiar to railroads and emphasize their individuality as contrasted to general research which considers problems of all industry.

c. Railroads should re-examine their recruiting methods for engineers and their policies and practices as regards training and utilization of engineers once they have been employed. The techniques and recommendations contained in Committee 24 reports and brochures should be consulted in this regard.

d. Where practicable, summer employment should be offered to university staff members. Your committee will continue to study and report on various aspects of and solutions to this problem.

e. The AAR might consider sending out a mimeographed sheet from time to time citing railroad research and engineering developments. This would go to all engineering schools and staff members or at least those who now receive so much economic and regulatory data and propaganda.

Part 2

Even before replies to the questionnaire had been received, the committee was in the process of implementing one idea later arising from the study. Depending principally upon suggestions from members of Committee 24 and their railroads, a list of railroad problems suitable for post-graduate research study has been compiled and will be distributed to accredited engineering schools and colleges, two copies to each dean.

The list of problems is inclusive of all areas of railroad interest. It is offered with the thought that students looking for suitable Masters and Doctoral research subjects will find topics related to railroads from which selections can be made. The list is of value in itself in pointing out the railroads realization of their need for research aid on many problems. Should a railroad problem be selected, the interest of the student and his advisor will be directed toward railroads. Finally, a successful study of and possible solution to the problem will be of direct benefit to the railroad or railroads which have that particular problem.

It need hardly be said that any railroad approached for information by a student working on any problem presented in this listing, should give the student access to its property and equipment and extend him every reasonable aid and courtesy.

To be worthwhile, this listing can not remain static but must be revised frequently. Your committee invites suggestions for additions or deletions. Where suggestions are made, it will be helpful if the railroad in question will indicate to what extent it is willing to furnish information and access to property as an aid in collecting data for solution of the problem.

SUGGESTED TOPICS FOR THESES ON RAILROAD SUBJECTS

The following initial compilation of railroad technical problems is composed of problems suggested by railroads represented in the AREA. It is intended for students seeking problems for Master or Doctoral research. The list is far from comprehensive and will, therefore, be revised at intervals so as to be more representative of the great extent and variety of problems to be found in railroad engineering and operation.

Accounts and Statistics

1. Develop a set of standard methods, possibly with the use of computers, which would produce figures to give a uniform means of cost comparison. One of the big difficulties in deciding on the type of equipment or the theoretical advantage of one system of maintenance over another is the problem of getting good cost figures on which to base an opinion. The ICC standards of accounting make it difficult to get actual cost figures on new methods. Each railroad tends to present its own ideas in the most favorable light. On many railroads, the efficiency of their particular operations is judged by a time study taken in one day or a half day, and does not take in account the long-range results or a monthly or yearly average.

2. Modify income accounting to include capital expenditures.

3. Develop depreciation reserve accounting for the Internal Revenue Service.

4. Modify Interstate Commerce Commission reports to an I.R.S. basis.

See also: Costs.

Ballast

See Bridges.

Bridges

1. Economics of design and fabrication of welded wide-flange beams and welded girders fabricated with steel plates, this study to determine the economical thickness of steel plates to be used in the webs and flanges of such beams and girders of various span lengths to accommodate railroad loading. This topic might include some discussion on the possibility of using horizontal stiffeners on the outside of webs to improve the appearance of girder spans.

2. Economics of various types of ballast troughs for supporting railway track ballast on railway bridges, taking into consideration service life, cost of maintenance, and effect of the dead load of the troughs. The following types of ballast troughs are suggested for study:

a. Wrought-iron plates provided with waterproof covering protected by asphalt plank to resist abrasion by the track ballast.
b. Creosote-treated timber with galvanized steel fastenings.
c. Reinforced concrete slabs:
   (1) Precast slabs
   (2) Poured-in-place slabs

This topic could also include a discussion of methods for installing ballast troughs on existing railway bridges so as to achieve minimum interruption to railway traffic.

Buildings

1. Study design, materials, and economies in using portable and semi-portable buildings, particularly prefabricated, at terminals and stations where flexibility due to changing needs is paramount.

2. Use of infra-red rays for heating shops, warehouses, and other miscellaneous railroad buildings.

Clearance

1. Design of a railway clearance car and/or equipment.

Communications

1. The application of microwave communications on railroads, both for use in special areas and eventually for general use to replace open-wire pole lines. The use of microwave as a means of communication on the railroads has barely been started, there being installations on the Santa Fe, Southern Pacific, Rock Island, and other railroads. During the next 10 years the use of microwave will no doubt be gradually enlarged; however, there are many unsolved problems.

Competition

1. The position and role of the railroads in the current highway and waterway development programs, and in the tremendous development of cities that is going on at this time.

2. Truck and rail freight-haul costs. Determine the zones of distance where truck haul is cheaper to the shipper on the basis of tons shipped. It is generally considered that, for short haul, the truck is cheaper; and also for less than car loads. However, for a given tonnage to be hauled there must be a "break even" distance beyond which the advantage in costs is in favor of the railroads. It is believed that a determination of this point would be of value to the shipper, if determined by a neutral, factual study of the problem.

3. Study to determine additional legislation necessary to permit operation of railroads on a more equitable competitive basis with subsidized and other forms of common carriers.

See also: Costs; Management.

Computers, Electronic

1. Review the savings to be realized by the railroad industry from the more general use of electronic computers, including the adoption of such equipment in railroad engineering departments.

2. Universal computer-oriented language for railroad engineering computer programming—writing computer programs for typical engineering problems suitable for any computer and any railroad.

3. A proposed universally acceptable waybill brought up to date in view of modern electronic business machines:

a. State of the art in "Character Recognition".

b. Machine identification of magnetic or similar ink, type face, etc.

4. Factors that will enter into computer solution of the question of long, slow, few freights vs. short, fast, frequent trains.

a. When is the optimum time to run a freight?

b. We lose business to trucks because they leave their terminals shortly after loading—on 3-min headway. Railroads frequently hold freight for a day "because Grandpa did." This is basically a topic in linear programming.

See also: Operations.

Costs

1. A restudy and revision of the "Yager Formula" of the AREA for determining the relationship and changes in annual costs of maintenance of way expense, due to changes in volume of traffic. This formula was originally determined during the federal control of railroads, and is now being revised to meet present methods and maintenance costs.

2. Make an up-to-date and more accurate determination of the relation between fixed and variable costs in the several systems of transport.

See also: Accounts and Statistics; Competition; Operation; Track.

Drainage

1. Effects of changes in land use on water runoff and culvert design.

Freight Stations and Freight Handling

1. Study materials and design of pallets and/or containers which will provide handling of less-carload lots and carload lots by fork-lift trucks. Most of the freight is presently loaded into and out of cars by hand, which results in high labor costs. This could be expanded into a study of economics resulting from manufacturers and processors packaging their goods on pallets or containers which can be handled as a unit through the wholesale warehouses to the retail outlet.

2. Study to determine what measures could be taken to reduce damage to commodities transported by rail and the cost of claims for such damage.

See also: Piggy-Back.

Legislation

1. Analysis of restrictive railroad legislation passed in the various states:

a. Justification.

b. Arbitrary character.
c. Need for constructive bills.

Location

1. Review, revise, and develop more accuracy in all railroad engineering design and location criteria.

2. Economics of grade and line revision—objectives: reductions in operating and maintenance costs.

See also: Operations.

Management

1. Planned allocations of resources for maintenance of way—budget forecast, revenue, and traffic factors, planning for steady base loads of work.

2. Investigate the advantages and disadvantages of broadening the deferred-payment method to cover large expenditures for additional railroad plant and equipment. Conditional sales agreements with manufacturers are used to cover large expenditures for furnishing and installing various types of permanent facilities, such as signals, interlocking, car retarders, etc. Also agreements with finance companies are used to cover lease of more expendable items, such as trucks and roadway maintenance equipment.

3. Study of the potential consolidation of railroad systems on a national basis and the problems involved, with suggestions for solving these problems.

See also: Competition; Legislation.

Operations

1. Study and development of ways and means to affect transit-time reduction between origin and destination of freight rail shipments.

2. What are the economic and operational factors affecting fixed-consist, light-tonnage, through-freight-train operation between major terminals, i.e., Chicago to the West Coast, New York through St. Louis or Chicago to the West Coast, etc.

3. What are the reasons for not advancing automatic remote operation of trains?

a. Technical developments needed.
b. Operational changes required.
c. Labor contracts.
d. Regulation by state bodies.

4. Can a railroad be run from a centralized point?

a. CTC.
b. Car dispatching or distributing.
c. Freight house.
d. Billing.
e. "Personal contact."

5. Determine the effects of railroad capacity and operation of varying geographical areas of the United States (for example, the short-haul, multi-terminal operation of eastern railroads as contrasted with the long-haul, and few terminals encountered, by railroads of the West; also mountainous terrain as contrasted to flat terrain, etc.)

6. Develop more nearly exact measures of track and traffic capacity for railroads. The increasing traffic load on line-haul and rapid-transit facilities and the need for increased efficiency in utilization of the minimum plant requirements make desirable an improvement in existing and cumbersome methods of computation. The adaptation of such new methods to computer solution should be included.

7. Evaluate various types of transport as to their relative engineering and economic efficiencies for various specific functions.

See also: Computers; Costs; Freight Houses and Freight Handling; Passenger Traffic; Piggy-Back; Rolling Stock; Weather; Yards.

Passenger Traffic

1. The role of railroads in commuter service as a result of suburban living.

2. Investigate what would be necessary to make passenger business a profitable operation.

3. A railroad with $1 billion invested in passenger facilities and equipment has an average revenue per passenger-train mile of $7. The full cost to the railroad is $9. If one train mile is taken off, the railroad saves $5. The railroad cannot increase the earnings per train mile to reduce the cost. At the same time it cannot very well take off a $7-per-mile train to save only $5 even though the full cost is $9. What is the answer? Note: The railroad proposing this question has offered full cooperation to the investigator in securing all pertinent data.

See also: Operations; Costs.

Personnel

1. The advantages to the individual, if any, for engineering students to become trained in railroad work by becoming student trainees with the railroad during each vacation period, with a job guarantee upon completion of the training and graduation, such as has been followed by the Southern Pacific Company; compared with enrolling students in trainee programs after graduation.

Piggy-Back

1. The advantages to truck transportation in costs by using the so-called piggy-back rail service for trailers, as against all-highway truck operation between similar origin and destination points.

2. Critical review of various methods for handling "Trailers on Flat Cars" (TOFC).

3. Probability of replacement of freight box cars by flat cars suitable for TOFC—influence on turn-around time, freight rates, operating costs, etc.

4. Investigate the various types of "piggy-back" and container transportation equipment and services now in use on railroads and determine which offers the greatest economic advantage, or recommend a new system which would have a greater economic advantage.

See also: Freight Stations and Freight Handling; Operations.

Piping

1. Study the feasibility of using plastic pipe to transport air, oil, and other materials around terminals.

2. Cathodic protection of underground steel pipelines and steel tanks, including methods for determining soil conductivity before making installations and including instructions for making tests after the completion of installations to ascertain whether proper protection has been achieved.

Rail

1. Study the flow of metal in rail. This could be an extension of the field of study opened up by C. J. Code's recent experiments of inserting brass plugs in the head of a rail and observing over a period of time the change in size and shape of these plugs due to the flow of metal in the head of the rail.

2. Program to determine economical rail size. This involves developing a guide to judgment in the economic selection of rail under different traffic conditions.

See also: Track.

Rolling Stock

1. Study the need for specialized freight equipment.

2. Plan to increase car ownership. One of the very pressing problems for the entire railroad industry is the freight-car shortage which occurs periodically during high levels of business. The Association of American Railroads has made frequent studies of this problem in conjunction with the officers of the railroads. Many suggestions have been offered to increase the ownership of cars, including higher per diem, national car pool, formula for individual railroad ownership, and other items. There is no plan so far submitted that has had any appeal to a majority of the railroads in any part of the country.

3. Ultimate effect, including cost analysis, to be gained by equipping all railroad cars and equipment with roller bearings.

4. Passenger comfort. Study designs of reclining seats which will allow passengers to relax comfortably. Most present seats do not provide satisfactory rest for the legs and head.

5. A study to determine what it is costing the railroads to provide specialized freight equipment versus freight equipment of standard design.

6. Study of the relative advantages or disadvantages—economic and mechanical—resulting from the use of roller bearings vs. friction bearings on railroad freight equipment.

7. Analyze the railroad journal-hot-box problem and develop recommendations for a practical and economically feasible solution.

See also: Operations; Passenger Traffic; Piggy-Back.

Signals

1. Evaluate the actual annual costs as between a section of double track compared with centralized traffic control on single track for the same volume of business. Several railroads have abandoned sections of double track by installing CTC on a single track, claiming large savings. These savings occur principally in maintenance.

Statistics

See: Accounts and Statistics.

Ties

1. Economics of tie spacing. The present practice is to place as many ties in track as possible and still have room to tamp around them. If the number of ties were reduced it is possible that they might have to be tamped more frequently, but tending to offset this would be the fact that there would be fewer ties to tamp, fewer ties in track to be maintained, and less investment in ties, tie plates and fastenings.

2. Tie renewal program. Tie renewals by the out-of-face method compared with individual renewals when the remaining life of individual ties is exhausted. Determine what percentage of a tie's total expected life can be economically thrown away in order to make renewals with specialized tie gangs, as against individual renewal when a tie is worn out.

See also: Track.

Track

1. Study effects of curvature on location and operation, and costs of railroad curvature. The increased resistance due to curvature, the causes thereof, the costs, and the effects of curvature on operation under modern conditions have been the subject of much contradictory evidence and argument. An impartial study could aid in establishing acceptable principles.

2. Investigate the status of the railroad track structure in the light of current and future types of motive power, speeds, axle loadings, equipment, and materials.

See also: Ballast; Cost; Operations; Rail; Ties.

3. Equation of track for maintenance. Top maintenance officers consider it quite a problem to equate track values so that each section foreman would be assigned approximately the same amount of work. It is the general experience that some sections are excellently maintained and others poorly maintained, and the question to be determined is whether in the first case this is due to the efficiency of the foreman or the fact that he is assigned less work to be done.

Tunnels

1. Ventilation of long railroad tunnels.

Weather

1. Sub-zero operation. Study the effects of sub-zero weather, snow, and ice on lubrication and on steam and air equipment on coaches and cars.

2. Effects of temperature on rail, joint bar, wheel, and axle breakage and the problems arising therefrom.

3. Effects of weather on overall speed of trains and on track and traffic capacity.

4. Effects of weather on speed of car movements through yards and on yard locomotive capacity; this would involve a study of tonnage ratings with the new types of motive power.

5. Variations in regional operating costs and problems due to weather.

6. Problems of weather imposed on specific commodities; for example, how much extra tonnage does a locomotive have to pull when cars of coal, sand, or ore are water-soaked or iced and how does this affect locomotive and traffic capacity? What are the effects of temperature on shipments of liquids and the effects on costs and capacities, etc.?

See also: Operation; Location.

Yards

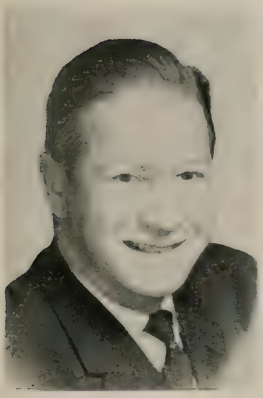
1. Factors influencing location and design of freight classification yards—mathematical models, systems design, instrumentation.

2. Interior illumination of railroad-yard control towers, with emphasis on elimination of glare or reflected light from windows.

3. Illumination of large railroad yards.

See also: Buildings; Operations; Weather.

Report of Committee 11—Engineering and Valuation Records



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C. F. Olson
D. G. Paeske
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J. B. Styles
J. R. Traylor
E. L. Vogt
R. C. Watkins
W. C. Wieters
J. L. Willcox**
H. R. Williams
Louis Wolf (E)
Committee

(E) Member Emeritus.
* Died January 26, 1959.
** Died February 19, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   One-third of the committee's Manual material is now under study, but no report.
2. Bibliography on subjects pertaining to records and accounts.
   Progress report, submitted as information ..... page 637
3. Office and drafting practices.
   Progress report, submitted as information ..... page 638
4. Use of statistics in railway engineering.
   Progress report, submitted as information ..... page 639
5. Construction reports and property records.
   Progress report, submitted as information ..... page 641
6. Valuation and depreciation:
   (a) Current developments in connection with regulatory bodies and courts.
   (b) ICC valuation orders and reports.
   (c) Development of depreciation data.
   Progress report on (a), submitted as information ..... page 643

7. Revisions and interpretations of ICC accounting classifications.
   Progress report, submitted as information ..... page 645
8. Simplification of records to determine original costs of tracks to be used in their retirements from the investment account.
   Progress report, submitted as information ..... page 646
9. Simplification of annual reports on Form 588 to the Interstate Commerce Commission, and underlying Completion Reports.
   Preliminary report has been sent to the AAR Accounting Division.

THE COMMITTEE ON ENGINEERING AND VALUATION RECORDS,
L. W. HOWARD, *Chairman.*

AREA Bulletin 555, January 1960.

MEMOIR

Arthur Thomas Powell

Arthur Thomas Powell, retired assistant chief engineer of the Grand Trunk Western Railroad, died suddenly at his home, 222 McKinley Avenue, Grosse Pointe Farms, Mich., on January 26, 1959, only five months after his retirement.

Mr. Powell was born in Athens, Ohio, August 19, 1893, a son of the late Reverend William and Marie Powell. He is survived by his wife, the former Mable Fairman, a son, 2 daughters, 20 grandchildren and 1 brother. Two sisters and one daughter predeceased him.

He graduated in civil engineering from the University of Kansas, where he was a member of the Delta Upsilon Fraternity. Following graduation he worked in the Engineering Department of the Elgin, Joliet & Eastern Railway. He entered the service of the Grand Trunk Western as a draftsman in the Valuation Department on September 1, 1916. During World War I he saw active service in France, holding the rank of Lieutenant in the 29th United States Engineers. On his return in March 1919, he resumed duties with the Grand Trunk Western and successively filled the positions of assistant engineer, engineer accountant and office engineer. On January 1, 1947, he was appointed assistant chief engineer. He played an important role in valuation work and the development of present accounting procedures.

Mr. Powell joined the American Railway Engineering Association in 1928 and was a Life Member at the time of his death. Shortly after joining the Association and continuously until the time of his retirement, he served actively as a member of Committee 11—Engineering and Valuation Records. His willingness to give generously of his time and wealth of experience endeared him to his associates who, with his wide circle of friends, deeply mourn his passing.

J. M. SMEATON, *Chairman,*
M. FRIEDMAN,
B. H. MOORE,
Committee on Memoir.

MEMOIR

Junius Law Willcox

Junius Law Willcox, retired engineer of statistics, Atlantic Coast Line Railroad, and a member of the American Railway Engineering Association, died on February 19, 1959,

in Wilmington, N. C., after an extended illness. In addition to Mrs. Willcox he is survived by a brother, James Willcox, Columbia, S. C., and a sister, Mrs. Edward Orr, Raleigh, N. C.

Mr. Willcox was born April 15, 1892, at Darlington, S. C. He attended the public schools there and graduated from Wofford College with an AB degree in 1912.

He was first employed by the Atlantic Coast Line in September 1912 as a rodman at Richmond, Va. He rose progressively through various positions in the engineering, construction, maintenance of way and valuation departments until he was appointed engineer of statistics in 1936. He retired February 1, 1959, from this position after serving 47 years with the Atlantic Coast Line.

Mr. Willcox joined the AREA in 1945 and was a member of Committee 11 from 1948 until the time of his death, during which time he contributed greatly with his valuable experience, his knowledge of railroad valuation, and his ever friendly willingness to contribute to the accomplishments of the committee. He will be remembered by his fellow committee members as one who always enjoyed his associations with his colleagues in this work.

In addition to his AREA affiliations, Mr. Willcox was a member of the Wilmington Engineers Club and the North Carolina Society of Engineers. He was a registered professional engineer in the State of Florida.

He was a member of the Presbyterian Church and a Mason, belonging to Orient Lodge, A.F.&A.M., Wilmington.

The American Raidway Engineering Association, Committee 11, and his friends, of which there are many, have suffered a great loss in his passing.

J. B. Styles, *Chairman,*
W. M. Hager,
B. H. Moore,
Committee on Memoir.

Report on Assignment 2

Bibliography on Subjects Pertaining to Records and Accounts

J. B. Byars (chairman, subcommittee), C. E. Clonts, M. Friedman, C. E. Lex, Jr., B. H. Moore, F. H. Neely, E. J. Rockefeller, W. C. Wieters, L. Wolf.

Depreciation

A new Concept of Measuring Accrued Depreciation. Public Utilities Fortnightly, January 15, 1959, page 73.

The Economic Liability to Replace—The liability-to-replace method measures accrued depreciation as an economic fact whether provision is made for depreciation or not. The physical or technological impairment of an asset, as measured by the equal percentage or straight-line method, is converted into loss of value by asserting the present worth of the dollar liability that must be met at time of replacement. Shown in practice to be virtually as accurate as lengthy engineering or "observed" methods, it is the study method of experts. The April 9, 1959, issue of this magazine gives a further discussion of this subject, page 562.

A State Commission Quiz on Depreciation Practices. Public Utilities Fortnightly, March 26, 1959, page 42.

A thoughtful compendium of how a state commission really feels about accelerated tax depreciation for public utilities. A survey of state commissions does not disclose any

clear-cut economic principle that works to determine capital costs. But some constructive depreciation considerations are pointed up that, if followed, should prove helpful guideposts in determining depreciation policy.

Depreciation and Capital Replacement in an Inflationary Economy. The Accounting Review, July 1959, page 367.

This article discusses the general subject of depreciation, including its function, the problems of relating depreciation to the current inflation and the various methods of depreciation recoveries. It also presents conclusions of the author as to the relations of depreciation to financial accounting.

Current Depreciation Allowances, an Evaluation and Criticism, by John Ryan.

Essentially this booklet is a well organized digest of the controversy over depreciation and inflation which has been waged in accounting literature since World War II. It discusses the scope of the depreciation problem, the development of depreciation policy and presents particular problems and attempted solutions. The appendices summarize treasury regulations relating to depreciation practices.

Economic Depreciation in Income Taxation and in Accounting. The Journal of Accountancy, April 1959, page 54.

The author contends that the United States economy now has a built-in bias toward inflation. He suggests that tax relief based on past and probable future inflation is needed to protect and encourage expansion of productive facilities. Four proposals for tax relief are discussed. While a preference is expressed for full adjustment of historical cost depreciation to current dollar cost, a modified form of "re-investment depreciation" is proposed as having a better chance of acceptance at the present time.

What Happens to Depreciation. Journal of Accountancy, March 1959, page 37.

In discussions of price-level adjustment of depreciation charges, the accumulated depreciation at retirement of an asset is often contrasted with the figure which would result from adjustment by the total change in the price level in the intervening years.

Accounting

Association of American Railroads Sampling in Railroad Accounting.

This report of sampling and its railroad applications was prepared by the AAR Special Committee for Simplification of Interroad Clerical Work with the assistance of the Operations Research Group of Case Institute of Technology, May 1, 1959.

Report on Assignment 3

Office and Drafting Practices

D. C. Paeske (chairman, subcommittee), W. A. Krauska, H. B. Sampson, R. L. Samuell, R. S. Shaw, Jr., H. A. Shinkle, J. R. Traylor, W. C. Wieter.

This is a progress report, presented as information.

Your committee previously reported on the several processes of duplicating records (Vol. 57, pages 595–598), and now calls attention to recent developments and improvements in equipment and materials, particularly those used in the processes applicable to office duplicating.

The processes most commonly used for office duplicating today are:

1. Diazo dye emulsion
2. Silver-coated media
3. Thermal sensitive
4. Dye transfer

No one process will provide maximum efficiency for all the duplicating requirements of several different offices; it is customary therefore, for each office to be equipped with a machine which will satisfy the major part of its needs. This often results in equipment standing idle part of the time and in being used inefficiently at other times.

It is the opinion of your committee that considerable savings, both in money and manpower, can be effected through centralizing the duplicating processes of several offices. Fewer machines would be needed, and more efficient use would be made of those which are required.

To this end it is suggested that studies be made to determine the duplicating needs of various offices and the feasibility of combining the duplicating facilities under one office.

Report on Assignment 4

Use of Statistics in Railway Engineering

M. C. Wolf (chairman, subcommittee), H. T. Bradley, J. B. Byars, S. Danby, V. H. Doyle, W. M. Hager, K. A. Heiny, L. W. Howard, B. H. Moore, C. F. Olson, H. L. Restall, E. J. Rockefeller, H. B. Sampson.

Service Lives of Depreciable Railroad Property

Your committee presents the following progress report as information.

Any determination of service life, other than a mere assumption, must be based on past experience. Using available mortality experience for a type of property, a dependable calculation of its service life can be made by the use of actuarial methods.

A number of study methods are described in standard textbooks, not all of which are applicable to the data available from railroad records. The most suitable means of analyzing the data for long-life property is the so-called "Annual Rate" method. For this purpose original installations are summarized in a column by dates of installation. In parallel columns, the subsequent retirements are summarized according to their age when retired.

From this type of summary, calculation is made of the percentage of original installations which survive at the beginning of each age interval, and of the percentage which is retired during the next age interval. By carrying this calculation through the years for which retirement experience is available, it is possible to draw a survivor curve representing the accumulated experience. By analytical means, or by fitting to standard-type curves, the derived survivor curve may be extrapolated to the point of total retirement of all the installations.

For the study of long-life property, such as masonry and brick buildings, it is recommended that an age interval of 5 years be used in summarizing the data. The minor inaccuracies in using this larger time interval offset each other, and it is almost impossible to detect all of the errors in posting which result from using the extremely large forms required for summarizing by single years.

Included is a sample summary of the mortality data, with calculation of points for determining the survivor curve. This summary, derived from the data from one company only, illustrates the method. The results are somewhat distorted by the extensive additions during the years 1927 through 1931, from which the retirements are insignificant. It is to be expected that combining the experience of a large number of companies would produce a smoother and more representative curve.

Acct. 16 - Masonry and Brick Depots - A.B.& C. R.R.

Summary of Original Installations and of Subsequent Retirements, Both by 5-Year Periods, and Calculation of Data for Survivor Curve.

Items "S" are the amounts of original cost which survive the periods for which retirement information is available.

Retirements by Average Age in Years When Retired

Period of Installation	Original Cost	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
		$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$
1947-1951	430,205				S=430,205																
1942-46	66,297					S=66,297															
1937-41	25,772			688			S=25,084														
1932- 36	-							S= 0													
1927- 31	1,099,507			200					S=1,099,307												
1922- 26	101,374					9457				S=91,917											
1917- 21	109,041		8961	6712				865			S=92,503										
1912 -16	605,163	500		23480			1035	5336	241			S=574,571									
1907- 11	158,637		55		1500		8917	14637	10175	8556			S=114,797								
1902- 06	302,005			1403	32205	1459		240	140	1258	8311			S=256,989							
1897- 01	303,659				15613	2000	68366		293	15256	4332				S=197,799						
1892- 96	53,656							515	4958	6925		18410				S=22,848					
1887- 91	237,120							11856	588	21586			11994	33094			S=158,002				
1882- 86	77,638							13855	2963		5463	2686	25583					S=27,088			
1877- 81	73,145										831	3861		9243	3070				S=60,832		
1872- 76	94,018												1240		2390	35	1376			S=35,525	
1867- 71	7,748											200		4925	600	1297	320	14090			S=6508
1862- 66	70,201																90	8997			42
1857- 61	83,256															1130	126	9135	9939		24474
1852- 56	65,563																				

A. Units retired during period:	500	9016	32483	49318	12916	78318	47304	19358	53581	18937	25157	38817	47262	6060	2462	1912	32222	9939	24516	-
Units at start of period:																				
B. No. of units	2,437,359	2,165,291	2,391,983	2,638,075	2,642,413	1,767,310	1,674,713	1,608,051	1,108,140	947,510	741,785	602,085	605,983	400,719	367,571	304,277	216,840	178,110	119,402	20,759
C. Per cent retired in period:	0.02	0.42	1.36	1.87	0.49	4.43	2.82	1.20	4.84	2.00	3.39	6.45	7.80	1.51	0.67	0.63	14.86	5.58	20.53	0.00
Per Cent of original units																				
D. At start of period	100.00	99.98	99.56	98.21	96.37	95.90	91.65	89.07	88.00	83.74	82.07	79.29	74.18	68.39	67.36	66.91	66.49	56.61	53.45	42.48
E. Retired during period	0.02	0.42	1.35	1.84	0.47	4.25	2.58	1.07	4.26	1.67	2.78	5.11	5.79	1.03	0.45	0.42	9.88	3.16	10.97	0.00
F. Surviving period	99.98	99.56	98.21	96.37	95.90	91.65	89.07	88.00	83.74	82.07	79.29	74.18	68.39	67.36	66.91	66.49	56.61	53.45	42.48	42.48

Note: Line A - Total Retirements for each age interval.

Line B - The total cost for which there is retirement experience in the succeeding period. The first item, 2,437,359, is the sum of original cost for the years 1912-1951. Deducting 500 retired in the period and 430,205 (Item "S" for the most recent period) and adding 158,637 (original cost for next preceding period of installation) produces 2,165,291, the next figure on Line "B". The last figure on Line "B", 20,759, equals the last Item "S" in the tabulation. This is the amount of original cost surviving 100 year experience.

Line E - Line C x Line D

Report on Assignment 5

Construction Reports and Property Records

W. S. Gates, Jr. (chairman, subcommittee), R. B. Aldridge, F. B. Baldwin, H. C. Boley, C. E. Bynane, C. R. Dolan, M Friedman, H. N. Halper, K. A. Heiny, J. W. Higgins, R. D. Igou, W. H. Kiehl, W. A. Krauska, C. E. Lex, Jr., B. F. Nauert, F. H. Neely, D. E. Pergrin, H. A. Shinkle, J. N. Smeaton, J. E. Stein, E. L. Vogt, R. C. Watkins, L. Wolf, M. C. Wolf.

The committee was instructed to design an index card for use in connection with record keeping for shop or other machinery. The sample machinery records and index cards submitted for study showed a very wide range of subject matter. They varied from a simple card to a complete layout. Because of this the committee is suggesting the basic card presented on page 642.

To guide the card designer of an individual railroad, a listing of the items that the committee considers should be given consideration is set forth below. The items actually used in any record-keeping system will be governed by the roads individual needs correlated into the space limitations of a 5- by 8-in index card.

Lists of Items That Should Be Considered

General Identification

- Name of machine
- Number of machine
- State, val. section and acct.
- City and shop
- Building number
- Dates built, in service, rebuilt, retired, etc.
- New or second hand
- Foundation
- Transferred to or from

Machine Drive

- Kind of drive
- Maker and Serial No.
- Ac, dc, voltage, cycles, phase, amperes
- Horse power or capacity
- Speed constant and variable
- Starting equipment
- Reference of replacement unit

Cost Data

- Installation and retirement project references
- Engineering report or BV 588 reference
- Dates, installed, retired, or replaced
- Purchased from
- New, second hand, or rebuilt
- Renumbering references
- Disposition of retired machines or motors
- Salvage recovered on retirement
- F.O.B. cost
- Freight charges—company and foreign
- Foundation cost
- Installation cost—machine, motor, electric service
- Additions and betterments
- Total cost and cost to date
- Original cost at 1910–14 prices
- Engineering report reproduction cost
- Cost to repair stored machines

MACHINERY INDEX CARD

(To be printed on an 8" x 5" index card)
Front Side of Card

Location _____ Machine No. _____
Name of Machine _____ New / SH ____ Motor No. _____
Maker _____ Serial No. _____ Building No. _____
Account No. _____
Size or Capacity _____ Speed _____ Foundation _____
Special Equipment _____

Installation: Year _____ Project _____ Retired: Year _____ Project _____

Remarks _____

Machine Drive: Kind _____ Maker _____ Type _____ HP _____
Serial No. _____ AC/DC, Volts, Cycles, Phase, Amperes _____
Speed _____ Starting Equipment _____

Installation: Year _____ Project _____ Retired: Year _____ Project _____

For Replacement Machine Drive See Index Card _____

Remarks _____

Complete Detail File on this Machine in File _____ Office of _____

Back Side of Card

Project References				Costs Reported			Detailed Cost Data
Year	AFE	CR	BV 588	Installed	Retired	Net Cost	State VS. ER Page
							Purchased from _____
							Orig. Cost
							Unit (Base Cost) $
							Frt. (Co.& Foreign)
							Installation Cost
							Electrical Items
							Foundation
							Tools & Specialties
							Miscellaneous _____
							TOTAL $
							Cost at 1910 to 1914 Prices $
TOTALS							

Remarks _____

Report on Assignment 6

Valuation and Depreciation

(a) Current Developments in Connection with Regulatory Bodies and Courts

C. R. Dolan (chairman, subcommittee), R. B. Aldridge, S. H. Barnhart, G. R. Berquist, H. T. Bradley, J. B. Byars, C. E. Bynane, C. E. Clonts, S. Danby, R. S. Danis, F. H. DeMoyer, V. H. Doyle, A. L. Engwall, W. S. Gates, Jr., E. W. Gibson, H. N .Halper, K. A. Heiny, J. W. Higgins, L. W. Howard, R. D. Igou, C. B. Martin, B. H. Moore, C. F. Olson, D. G. Paeske, H. L. Restall, C. S. Robey, E. J. Rockefeller, J. B. Styles, E. L. Vogt, H. R. Williams, M. C. Wolf.

ICC Bureau of Accounts, Cost Finding and Valuation, Section of Valuation

The Section of Valuation was engaged principally during the year in railroad and pipeline work, preparing tentative and final valuations for pipeline carriers. During the year statements were prepared showing the elements of value for all Class I line-haul carriers and switching and terminal companies as of December 31, 1957.

During the year 1958, Class I line-haul carriers charged Account 459—Valuation Expenses, $861,644 contrasted with $829,139 for the year 1957.

As of October 1, 1959, all pipeline and rail carriers were practically on a current basis in the filing of valuation reports with the Bureau, with the following exceptions: 7 line-haul carriers and 1 switching and terminal company not filing for the year 1956 and 19 line-haul and 4 switching and terminal companies for 1957. Valuation reports covering property changes for the year 1958 have been received from 29 line-haul and switching and terminal companies and 64 pipeline carriers.

The backlog of valuation work (rail and pipeline carriers) in the Bureau as of October 1, 1959, was as follows:

	Annual Valuation Reports
Engineering inventories	1,661
Present value of land and rights	737
Original cost summaries	49

The total authorized personnel for valuation work in the Section of Valuation on October 1, 1959 was 44.

During the year the Commission issued Orders or Notices covering the following valuation matters:

Order issued revising the valuation regulations governing the report of property changes by pipeline carriers.

Notice issued relieving the Pullman Company from filing Forms B. V. 588–R "Report of Property Changes."

In addition to the above, the Commission released the railroad and pipeline construction indices for the year 1958.

Report of the Committee on Valuation, National Association of Railroad and Utilities Commissioners

The above-named committee recently issued its annual report for 1959, consisitng of a text of 10 pages, with an appendix containing a list of the cases cited in the report. Copies may be secured from the Office of the Secretary, National Association of Railroad and Utilities Commissioners, Room 5310, Interstate Commerce Commission Building, 12th and Constitution Avenue, N. W., Washington 25, D. C., price 50 cents per copy.

The question of "attrition", which the committee discussed at length in last year's

report, is again reviewed in the light of the 1958 recession and the continued rise in prices. Under the heading of "Fair Value" a number of court cases are cited in which utility commissions were required to give consideration to reproduction-cost evidence. However, the statement is made that there has been no change in the number of states utilizing the fair value rate base.

The report concludes with the following summary:

"As has been stated in an earlier report of this committee, the heart of the problem facing regulators is how to give proper effect to current economic conditions. Valuation conditions and policies cannot be static but must mesh into the evolutionary processes of our time.

"We know from the history and evolution of rate making that utility regulation can be adjusted to changing times. It is dynamic. Adequate procedures and practices of regulation in one period may not be adequate or practical in another. Conditions have changed radically since the decision in the Hope Natural Gas Case. In the intervening years, the price level has increased by about two-thirds.

"In view of the changed conditions over these years, it is apparent that all regulatory agencies must take into consideration the rising price level to ascertain whether adequate value is measured in providing fair rates of return. Proper valuation is imperative to maintain a healthy utility industry in condition to meet the challenge of the future growth of our economy."

Retirement—Straight Line Adjustment Act of 1958

Section 94 of Public Law 85–866 (H.R. 8381), which was approved by the President on September 2, 1958 (also known as Section 94 of the Technical Amendments Act of 1958), eliminates the contention surrounding the 30-percent depreciation reserve that was imposed on the railroads as a condition to their changeover from retirement to depreciation accounting on road property for income tax purposes after 1941.

The section provides that any taxpayer who changed from the retirement method of accounting for income tax deductions to the straight-line method of computing depreciation for any taxable year after December 31, 1940, and before January 1, 1956, may elect to have it apply. Its application will have the effect of reducing the 30-percent depreciation reserve after adjustments specified in the Act. The difference will be added back to basis for future recovery after December 31, 1955, based on the estimated remaining life of such property. In general, this will result in larger annual depreciation deductions. While an election under this section precludes any refunds attributable to depreciation for the period 1942–1955, it permits adjustment of the so-called "equity invested capital base" for the determination of excess profits tax liability for World War II and the Korean War profits where circumstances warrant it. If applicable, this should increase the excess profits credit and decrease the income subject to the excess profits tax, resulting in refunds of the taxes paid during those periods.

Final implementing regulations were published in the Federal Register of October 13, 1959. Among other things, they provide that railroads may elect to have the provisions of the Act apply by filing a statement to that effect within 90 days from the date of publication.

Report on Assignment 7

Revisions and Interpretations of ICC Accounting Classifications

M. M. Gerber (chairman, subcommittee), S. H. Barnhart, C. E. Clonts, C. R. Dolan, A. L. Engwall, W. S. Gates, Jr., W. M. Hager, C. B. Martin, B. H. Moore, F. A. Roberts, C. S. Robey, H. B. Sampson, J. R. Traylor.

This is a progress report, presented as information.

1. ICC Docket No. 32153—Proposed Modification of Uniform System of Accounts for Railroad Companies. This proposal provides for the elimination of betterment accounting for track elements and the substitution therefor of depreciation accounting Presentations filed on behalf of the rail carriers in regard to this matter are still under consideration by the Commission.

2. It is proposed to cancel Interpretations of Accounting Classifications embodied in Accounting Bulletin No. 15 and retain as "A" cases those currently applicable. The Accounting Division, AAR, has made an analysis of individual cases and submitted copies of the report for review to C. W. Emken, director, ICC Bureau of Accounts, Cost Finding and Valuation.

3. Proposal to increase the minimum charge to investment from $500 to $1000 is under consideration by the General Committee of the Accounting Division, AAR, and has been referred to a Contact Committee for study and exploration with Mr. Emken.

4. ICC Subject No. 467, Disposition of Balances in Account 733—Acquisition Adjustment.

ICC proposes to clear all balances from Account 733—Acquisition Adjustment, resulting from mergers, consolidations, reorganizations, receiverships, and purchases. These balances represent the difference between actual considerations given, and assets and liabilities acquired, and recorded to conform to the requirements of the Commission.

It is proposed to dispose of any credit balance through depreciation reserve and other reserve accounts and to capital surplus. A debit balance is to be cleared to Account 80—Other Elements of Investment.

5. ICC Subject No. 468, Redistribution of Amounts to Primary Road and Equipment Accounts.

ICC proposes that amounts recorded in the primary accounts classified under balance sheet Accounts 731—Road and Equipment Property, and 732—Improvements on Leased Property, shall be cleared from the primary accounts and shall then be redistributed to primary accounts in the following manner:

Amounts shall be included in the appropriate primary road and equipment accounts at original cost as shown in the valuation records, except for land. Lands used in transportation operations shall be recorded in the primary accounts for land at original cost reported in basic valuation reports under Valuation Order No. 7. Lands reported without cost in order No. 7, except those donated, shall be recorded at their estimated original cost, subject to approval of the Commission, and to such sum shall be added the original cost at time of dedication to transportation purposes of land subsequently acquired and so used.

The remaining amount, adjusted as may be necessary to conform with the accounting rules of the Commission, shall be recorded in primary road and equipment property Account 80—Other Elements of Investment, if a debit; and in a subdivision of balance sheet Account 735—Accrued Depreciation, Road and Equipment, if a credit.

Report on Assignment 8

Simplification of Records to Determine Original Cost of Tracks to Be Used in Their Retirements from the Investment Account

C. F. Olson and B. F. Nauert (co-chairmen, subcommittee), R. B. Aldridge, G. R. Berquist, S. Danby, F. H. DeMoyer, C. R. Dolan, V. H. Doyle, W. S. Gates, Jr., M. M. Gerber, H. N. Halper, N. Hammond, L. W. Howard, R. D. Igou, C. E. Lex, Jr., C. B. Martin, J. K. Morrissey, F. H. Neely, D. G. Paeske, D. E. Pergrin, H. L. Restall, F. A. Roberts, C. S. Robey, H. B. Sampson, R. S. Shaw Jr., E. L. Vogt, L. Wolf.

Determination of Average Unit Costs of Track Components to Be Used in Retiring from the Investment Account (Ledger Value) for Accounting Purposes

This is a final report on this phase of the assignment, and is submitted as information.

During the years subsequent to the Federal Inventory of Railroads, the basic property records of most carriers have grown to such an extent that it is burdensome and virtually impossible to determine accurately ledger value retirements of the various components in the track accounts.

The track accounts include: Account 8—Ties, Account 9—Rails, Account 10—Other Track Material, Account 11—Ballast, and Account 12—Track Laying and Surfacing. Accounts 9, 10 and 11 have become particularly complicated as a result of betterment accounting. Under this form of accounting the amount capitalized is the excess cost of new parts over the cost at current prices of new parts of the kind replaced.

The investment account consists of either Engineering Report (ER) Cost of Reproduction New plus net Valuation Order No. 3 (VO 3) changes, or actual original cost to the carrier at ER date plus net VO 3. Many carriers have adopted Engineering Report Cost of Reproduction New as ledger values for property in existence as of date of basic valuation. Whether a carrier uses ER or has available actual original cost as the basis for ledger value, the tremendous volume of property changes since valuation date has created the same difficult problem in determining a current basis for retirement purposes.

The method outlined herein to determine average unit costs for retirement purposes is predicated on the basis that the carrier either has or can produce a property record which provides the following information:

1. Record of costs for each Account and Valuation Section, showing:
   a. Additions and betterments of property installed, ER to date.
   b. Retirements from ER. (If carrier perpetuates actual original cost of ER property it is also necessary that original costs be restated to ER Costs.)
   c. Retirements from VO 3.
2. Record of units or components installed and retired.
   a. Basic inventory total of ER units and subsequent retirements from same.
   b. Subsequently installed VO 3 units and retirements from same.

In order to simplify the determination and use of average costs for retirement purposes it is recommended that the property record limit the number of components or units within each account to the fullest possible extent. The tie account should be limited to main-track cross ties, side-track cross ties, switch ties, and bridge ties; also whether treated or untreated. Rail should be limited to new, second hand and welded.

In the other track material account the use of hundred-weight (cwt) as the unit should be used as much as possible. Ballast units should be confined to as few classes as practicable.

Retirement accounting involves four distinct classes of retirements, as follows:

1. ER units of property
2. VO 3 units installed as betterments of ER property.
3. VO 3 units installed subsequent to ER and not affected by betterments.
4. VO 3 units installed subsequent to ER which have been affected by betterments.

It is recommended that average costs for retirement purposes be limited in scope to individual valuation sections and that two sets of costs be used for each section—the first for ER units and the second for VO 3 units. The calculation of average costs by valuation sections should be commenced with a determination of the total investment in each account. For those carriers that have accepted ER as original cost, it is simply the sum of total ER plus VO 3 additions and betterments added, minus all retirements as of any given year. For those carriers that use their own original cost of ER property, the total investment in each account should be determined by using the most accurate information available.

The next step is to determine the portion of the investment account to be allocated to the remaining ER units, using the same unit costs as assigned therein. In this connection some carriers may find it feasible to change certain ER units from "each" to "cwt" to simplify the accounting of such units. For those carriers whose records are based on their own original cost plus VO 3, it is recommended that the remaining ER units be assigned calculated unit costs developed by modifying the ER unit costs on the basis of the percentage relationship which the total cost of these units at ER unit costs bears to the total cost assigned to them in the investment account. The method to be used in determining this percentage relationship will vary for each carrier, as each carrier's basic records will be different from that of another. It is necessary to use the most accurate information available.

The difference between the present total investment account and the amount assigned to remaining ER property represents the amount to be allocated to the remaining VO 3 units. Average unit costs for VO 3 property should be calculated by commencing with a set of representative average unit costs, using the best cost data available, and then adjusting these costs by the percentage of deviation to balance the total portion of the investment account assigned to VO 3 property.

In arriving at average VO 3 unit costs, consideration must be given to the effect of betterment accounting. It must be borne in mind that unit costs for retirement from the investment account must contain the cost of the original installation plus the net cost of successive net improvements. For example, let us examine the ledger value of present 112-lb rail, which was 90-lb rail in the ER at $30 per ton and was relaid in 1940 with 112-lb rail at $45 per ton. The ledger value of the 112-lb rail would then be developed as follows:

Weight of Rail	*Unit Cost per Ton*
90-lb rail:	
$\frac{90}{112} \times 30 =$	$24.11
22 lb increased weight of the 112 lb:	
$\frac{22}{112} \times 45 =$	8.84
112-lb rail	$32.95

After average unit costs have once been determined they can be perpetuated on an annual or period basis, depending on the amount of property changes. On branch lines and certain other valuation sections where property changes have been light subsequent to ER date, average unit costs would not be necessary.

It is not recommended that average unit retirement costs be used for consequential retirements from VO 3 when actual costs can be easily and accurately determined.

Average costs can be used to good advantage when the retirement is from numerous prior authorities for expenditure involving additions and betterments, both in saving time and attaining greater overall accuracy of retirement costs.

Report of Committee 1—Roadway and Ballast

G. B. Harris, *Chairman,*

F. N. Beighley, *Vice Chairman,*

L. J. Deno, *Secretary,*

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A. P. Crosley (E)
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F. W. Hillman (E)
H. O. Ireland
H. G. Johnson
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R. J. Kemper
H. W. Legro (E)
R. R. Manion
P. G. Martin
G. D. Mayor
E. W. McCuskey
R. L. McDaniel
Paul McKay (E)
W. G. Murphy
F. R. Naylor
G. F. Nigh
S. J. Owens
A. J. Pacelli
A. C. Parker, Jr.
G. W. Payne (E)
W. F. Petteys
J. W. Poulter
J. W. Purdy
C. W. Reeve
L. G. Reichert
K. W Schoeneberg
R. W. Scott
G. E. Shaw
G. S. Sowers
C. E. Stoecker
J. M. Thomson
W. O. Trieschman
Stanton Walker
C. E. Webb
A. J. Wegmann
Charles Weiss*

Committee

(E) Member Emeritus.
* Died July 26, 1959.

To The American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   See report on Assignment 4.

2. Physical properties of earth materials:

   (a) Roadbed. Load capacity. Relation to ballast. Allowable pressures.
   Final report, submitted as information ..... page 652

   (b) Structural foundation beds, collaborating with Committees 6 and 8.
   Progress report, submitted as information ..... page 653

3. Natural waterways: Prevention of erosion.

   Progress report, submitted as information ..... page 658

4. Culverts:

   (a) Erosion control for outlet structures.
   Research on this assignment was started in 1958 as a three-year project. Budget curtailment in 1959 forced cancellation. It is hoped that work will be resumed this year at Colorado State University as originally planned.

   Recommendation for revisions to Specifications for Corrugated Metal Pipe for Subdrainage ..... page 663

5. Specifications for pipelines for conveying flammable and non-flammable substances.

   Progress report, submitted as information ..... page 665

6. Roadway: Formation and protection:

   (a) Roadbed stabilization.
   Progress report, submitted as information ..... page 670

   (b) Slope protection by use of additives.
   Information has been gathered from various sources and is now being assembled and studied. Preliminary draft of proposed Manual material to be submitted in 1961.

   (c) Performance of filter materials in subdrains.
   Progress report, submitted as information ..... page 677

   (d) Gypsum treatment of subgrade to improve track drainage.
   This is a new subject. The Chesapeake & Ohio is conducting the only railway experiment with this material that has come to the attention of the committee. Thus far, the results have been inconclusive, but the test is expected to be continued.

7. Tunnels:

   (a) Ventilation: changes necessary for operation of diesel power.
   Progress report, submitted as information ..... page 693

   (b) Clearance; methods used to increase, collaborating with Committee 28.
   A list of methods that have been used in the past is now being developed, including cost data insofar as possible. The ultimate aim is possibly to recommend new methods that might be used for future work.

8. Fences.

   The present specifications for fence posts, shock fences and stock guards are now being reviewed prior to submission in 1961 and 1962 for reapproval or revision. There is no specific subassignment under this assignment.

9. Roadway Signs:

   (a) Reflectorized and luminous roadway signs, collaborating with Committees 5 and 9 and with the Signal Section, AAR.
   Due to curtailment of research funds, Committee 1 did not request funds for continuation of this study by the Armour Research Foundation. A survey of commercially available nuclear light sources revealed that these sources were not available for signs, but inasmuch as new products are coming out almost daily. the committee felt it should look into the subject further before recommending that it be discontinued.

   (b) Develop standard close clearance warning sign, collaborating with Committee 28.
   Several tentative plans have been prepared which have been circulated, but to date conclusions have not been reached as to the best design.

10. Ballast:

   (a) Tests.
   As the result of the curtailment of funds in the 1959 budget, ballast tests at the AAR Research laboratory have been discontinued. It is

hoped, however, that funds will become available in the near future to resume these tests which are expected to result in improved understanding of ballast problems and thus gain an improved return for an important item in annual maintenance expenses.

(c) Special types of ballast.

Progress report, submitted as information ..... page 715

11. Chemical control of vegetation, collaborating with Signal Section and Communications Section, AAR.

Progress report, submitted as information ..... page 725

THE COMMITTEE ON ROADWAY AND BALLAST,
G. B. HARRIS, *Chairman.*

AREA Bulletin 556, February 1960.

MEMOIR

Raymond Arthur Gravelle

Committee 1 records with deep regret the death of Raymond Arthur Gravelle, engineer maintenance of way, Grand Trunk Western Railroad, Detroit, Mich. Mr. Gravelle became a member of the Association in 1927. He was a member of Committee 5—Track, 1941–1949; Committee 1—Roadway and Ballast 1949–1958, and Committee 22—Economics of Railway Labor, from 1958 until the time of his death.

A more complete Memoir on Mr. Gravelle appears in the current report of the Committee on Economics of Railway Labor.

MEMOIR

Charles Weiss

Charles Weiss, retired research analyst, Pennsylvania Railroad, died at St. Vincent's Hospital, Portland, Ore., on July 26, 1959, in his 68th year. He is survived by his wife, Sari Weiss, his son Robert L. Weiss of Oswego, Ore., and his daughter, Mrs. Mary Anne Brahana of Athens, Ga.

Mr. Weiss was born in Hungary on June 27, 1891. He graduated from Cornell University in 1913 with a B.S. degree in Civil Engineering.

Mr. Weiss entered railroad service June 14, 1913, as a rodman with the Pennsylvania Railroad. He advanced to assistant supervisor, supervisor and assistant engineer in the Maintenance of Way Department and was appointed research analyst in the Research and Development Department on February 1, 1956, from which he retired on May 1, 1958. During his career on the railroad Mr. Weiss not only devoted his energies to his chosen career, but also contributed widely to technical magazines, as well as being the author of several textbooks on railroad engineering.

Mr. Weiss became a member of the American Railway Engineering Association in 1947. From 1948 until 1950 he was a member of Committee 9—Highways. In 1950 he was appointed to membership on Committee 1 from which he resigned in June 1959. From the time of his association with the AREA until his death he was sincerely interested in furthering its aims and was diligently active in its projects.

It is with a deep sense of appreciation by those who knew and worked with Mr. Weiss that this tribute to his memory is recorded with the American Railway Engineering Association.

Report on Assignment 2

Physical Properties of Earth Materials

(a) Roadbed. Load Capacity. Relation to Ballast. Allowable Pressures
(b) Structural Foundation Beds, Collaborating with Committees 6 and 8

W. P. Eshbaugh (chairman, subcommittee), H. F. Davenport, C. E. Dysart, J. G. Gilley, H. O. Ireland, R. R. Manion, J. W. Poulter, Charles Weiss.

Under this assignment your committee presents as information two reports, both containing material applying to Assignments (a) and (b).

The work reported is part of the committee-sponsored research program of the Research Department, AAR, under the general direction of G. M. Magee, director of engineering research, and under the supervision of Rockwell Smith, research engineer roadway. G. L. Hinueber, engineering laboratory manager, performed the field work and prepared the reports, assisted in the work for Part 2 by H. M. Sutcliffe, research technician.

Part 1—Soil Pressure Cells

This is the concluding report on the use of soil pressure cells for measurement of static soil pressure and changes in static pressures that may occur over relatively long periods of time under high embankments. The work was carried on as part of an investigation of stresses in concrete culvert pipes sponsored by Committee 30—Impact and Bridge Stresses. The measurement of the earth pressures was sponsored by Committee 1.

The test installation was under the Louisville & Nashville Railroad hump yard in Atlanta, Ga. A detailed description of the installation, as well as a description of the types and modifications of soil pressure cells used, appears in the Proceedings, Vol. 59, 1958, page 799.

It was hoped that by the installation of modified and improved soil pressure cells direct information might be obtained on the development of stresses and changes in stresses that occur within earth masses over relatively long periods of time.

Pressure readings from the cells were taken five times during construction operations and three times subsequent to the completion. Seven of the eight pressure cells functioned well during the construction period. There was generally good agreement between measured and theoretical pressures. However, at the time of the first readings following completion of construction, four of the eight cells were inoperative and a fifth cell was giving erratic readings. Only the two AAR Type II cells and one of the two Waterways Experiment Station cells were recording faithfully. The last readings were taken one year and three months later, and at that time five of the eight cells were completely inoperative.

In view of the failure of the majority of the soil pressure cells and the consequent lack of data, the investigation will be discontinued.

Part 2—Nuclear Moisture and Density Measurements

Introduction

This report deals with the use of nuclear-activated moisture and density probes for the rapid measurement of soil moisture content and density, both at and below the

surface. With this equipment it is possible to obtain soil moisture content and density in the field with an acceptable degree of accuracy in only a fraction of the time required by present conventional methods. These determinations can be made on the surface or to any depth below the surface down to 60 ft with the present equipment.

The surface equipment lends itself to making surface moisture and density checks, both during and after construction, and the subsurface equipment appears to have a great future value in the location of the cause of fill instability.

Theory and Description of Equipment

The general operating principle of the equipment is based on the varying degree in which radiation from a radioactive source is scattered when it contacts materials of different moisture content and density. The measurement of this scatter gives a means of determining the moisture content or density of the material being tested.

The moisture probe contains radium–beryllium, which is a source of fast neutrons. When the probe is placed in contact with the soil, the fast neutrons from the source collide with nuclei of atoms of water and soil, giving up some energy with each collision. As the collision-scattering and energy-reduction process continues, some of the neutrons gradually reach a lower energy level and become slow neutrons.

The energy loss by fast neutrons is much greater in collisions with atoms of low atomic weight. Since hydrogen is the only material of low atomic weight found in most inorganic materials, and since the hydrogen is mostly contained in molecules of free water, the slow neutron count becomes a measure of the moisture content.

The moisture probe has a detector which detects only slow neutrons and is used in connection with an instrument called a scaler which records the electrical impulses produced in the detector by the slow neutrons.

The density probe contains cesium–137, which is a source of gamma rays. When the density probe is placed in contact with a soil, the gamma rays collide with electrons in the outer orbit of atoms comprising the soil and are scattered in all directions. As the density of a material is increased the scattering power increases. The gamma ray, however, loses energy with each scattering process, and each scattering increases the probability that the gamma ray will be absorbed before it reaches the detector. The combined effect is that the denser the soil the fewer will be the number of rays returning to the detector; hence the density is inversely proportional to the number of counts. The detector that counts the back-scattered gamma rays is contained in the probe and the scaler records the count.

Calibration

In order to correlate the rate of count with the moisture content or density, as the case may be, each of four probes was calibrated. For this purpose materials of varying known moisture content and density and a 55-gal drum were used. A piece of cold-drawn seamless steel tubing, 20 gage with an outside diameter of 1⅝ in, was driven into the center of the drum as an access tube or casing for use with the subsurface probes. A special calibration must be obtained for accurate work with any other type of casing.

With the data obtained calibration curves were drawn by plotting counts per unit time against moisture content or density. The calibration curves for the moisture probes cover a range for soil material from 0 to 32 lb of water per cu ft. The calibration curves for the density probes cover materials in a range of 60–160 lb per cu ft wet density.

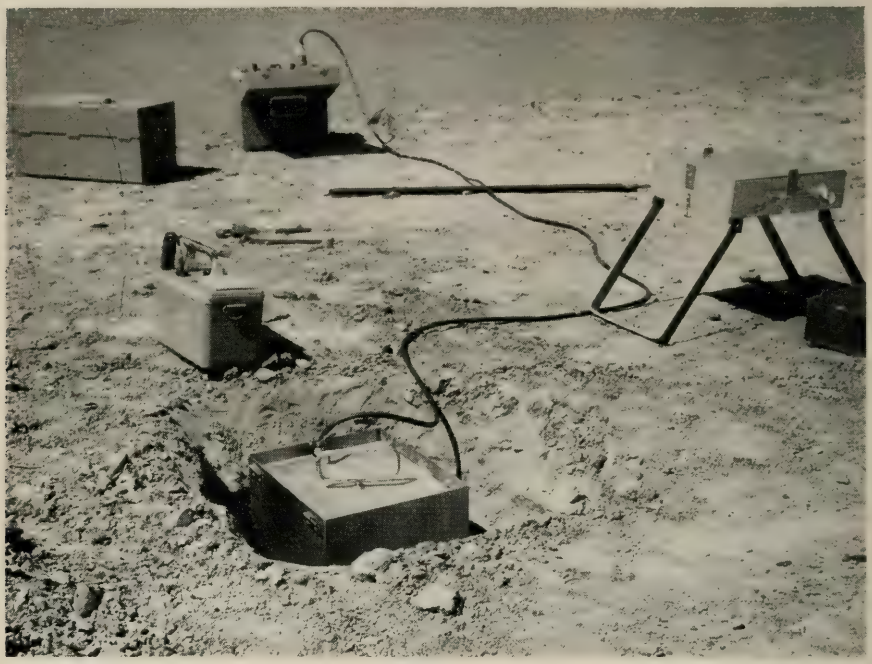

Fig. 1.

Operating Procedures

The procedure for the use of the surface moisture probe or surface density probe consists of placing the instrument which contains the radioactive source and detector flat on the surface of the ground, which had been previously leveled. By depressing the handle of the probe the radioactive source is removed from its shield and placed in position where its rays may penetrate the soil. The amount of backscattering per unit time is then measured by the detector in the probe and recorded by a portable scaler. Fig. 1 shows the surface nuclear moisture probe being used for determining the moisture content of surface soils. Fig. 2 shows the surface nuclear density probe being used for determining the density of surface soils.

The procedure for operating the subsurface moisture probe or subsurface density probe, which contains a radioactive source and detector, consists of lowering the probe into a hole which has been bored by augering and driving a 1⅝-in 20-gage steel tube into the soil. The amount of back scattering per unit time is measured by the detector in the probe and recorded by a portable scaler. Fig. 3 shows the calibration of the subsurface nuclear moisture probe being checked.

Test Program

The nuclear moisture and density probes were used experimentally for both surface and depth determinations at several locations on the Frisco Railway Keystone Dam revision west of Tulsa, Okla. The soils on this job ranged from sand to sandy clay, clay and shale.

Fig. 2.

A number of readings were taken with the surface moisture and surface density nuclear probes. At the same time samples were taken at the same locations for determination of moisture by the standard drying method and determination of density by the balloon volumeasure method (Fig. 4). With these data a comparison can be made between the results determined by the nuclear method and those determined by present standard methods.

Holes for the nuclear subsurface moisture and density probes were made by augering and driving the 1⅝-in thin-walled steel tube.

Soil samples were taken at 1-ft intervals, and moisture contents were determined by the usual method of oven drying. The subsurface nuclear moisture probe and the subsurface nuclear density probe containing the radioactive source and detector were lowered into the cased hole in turn, and the moisture and density measurements were taken at 1-ft intervals. Comparisons were made between moisture contents taken by sampling and oven drying.

The following table shows the close agreement in these comparative results of surface moisture determinations using these two methods.

Location	*Surface Moisture Content Standard Method*	*Surface Moisture Content Nuclear Method*
Station 1371—Section 4 (Sand Fill)	10.3%	9.4%
Station 1038+25—Section 3 (Sandy Clay Fill)	12.2%	12.4%

Fig. 3.

Fig. 4.

The following table shows the close agreement in comparative results of surface density determinations using the standard method and nuclear method.

Location	*Surface Wet Density Standard Method*	*Surface Wet Density Nuclear Method*
Station 1371—Section 4 (Sand Fill)	132.0 lb per ft³	128.5 lb per ft³
Station 1038+25—Section 3 (Sandy Clay Fill)	125.5 lb per ft³	124.0 lb per ft³
Station 872+75—Section 2 (Shale Cut)	140.0 lb per ft³	138.7 lb per ft³

The following table gives comparative results between conventional and nuclear methods for subsurface moisture determinations. Samples were taken at 1-ft intervals, using a soil auger, and moisture contents were determined by drying. Nuclear moisture determinations were made at the same depths at the same location.

Location	*Depth*	*Moisture Content Standard Method*	*Moisture Content Nuclear Method*
Station 1038+25—Section 3 (Sandy Clay Fill)	1 ft	13.2%	15.8%
	2 ft	20.4%	18.2%
	3 ft	19.6%	18.0%
	4 ft	15.5%	18.7%
	5 ft	14.9%	18.2%
	6 ft	16.3%	20.5%
	7 ft	14.6%	16.0%
	8 ft	10.0%	12.7%
	9 ft	12.2%	13.1%

The results are in fairly close agreement. The average variation between the standard method and the nuclear method is 2.4 percent moisture. The variation may be due in part to the fact that the nuclear moisture depth probe measures a considerably larger volume than that taken by the 1½-in auger used in the boring and sampling operation. Another possible source of error lies in the fact that the moisture samples were dried rapidly over an open gas flame rather than in an oven at controlled temperature and time.

It is impractical to try to compare the results of the subsurface density determinations using the nuclear probe with those taken at proximate locations during construction using conventional methods, as the construction control tests were not located by definite stationing. Also, the field density taken during construction is subject to change due to such factors as subsequent rainfall and passage of construction equipment and increased height.

Although the data for this job are limited, it is considered sufficient to prove out the apparatus. Additional work is planned which should permit a more complete understanding of the capabilities and limitations of the equipment.

Conclusions

1. Moisture contents and densities obtained with the nuclear probes agree with those obtained by conventional methods within limits reasonable enough to permit the use of this equipment for general engineering use and construction control.

2. The use of the nuclear equipment is relatively simple, safe, portable and rapid.

3. The surface probes eliminate the necessity of laboratory work for determination

of surface moistures and densities. Results can be obtained within minutes in the field, and their use can result in saving appreciable inspection costs on large projects.

4. The subsurface probes allow relatively accurate, rapid, moisture and density determinations at considerable depths and appear to offer valuable possibilities in determining locations of fill instability.

Report on Assignment 3

Natural Waterways: Prevention of Erosion

G. W. Becker (chairman, subcommittee), R. A. Anderson, B. H. Crosland, J. K. Fisher, F. R. Naylor, J. M. Thomson.

In 1955 your committee presented as information a report on prevention of bank erosion in natural waterways through the use of steel jetties and fascine boxes (Proceedings, Vol. 56, 1955.) Supplemental reports on additional types of protection were submitted in 1957 (Proceedings, Vol. 58, 1957), and in 1959 (Proceedings, Vol. 60, 1959). In the latter report, under the title "Steel Jetties", there was offered a brief discussion of the possible effect on jetty installations resulting from clear or desilted water being discharged from upstream reservoirs.

The current report presents data illustrating the degradation effect occurring downstream from three different reservoirs, and discusses the probable effects of such action on existing or proposed bank protection below a reservoir.

Since the material used in making the accompanying graphs is unofficial in nature at this time, the three locations described have been designated only as Dams "A", "B" and "C". The drainage areas above the three reservoirs vary from 12,000 to 180,000 square miles and are located on streams normally carrying a heavy silt load during periods of high discharge.

Suspended Sediment—Some of Its Relations to Bank Protection

As a rule, bank protection is placed with at least one of two purposes in mind: (a) to stop erosion at the time of placement, usually through use of riprap bank lining, and (b) to train or "push" a stream back to an improved alinement by use of steel jetties, stone jetties or permeable dikes. These latter types of protection may also afford some lessening of bank loss through reduction of eroding velocities in the stream, but they largely depend on dropping part of a river's silt load to accrete or build up new bank material. Thus, if a stream is relatively clear or has been desilted by a reservoir, permeable protection will not perform in the manner intended.

The dashed line in Fig. 1a shows a typical suspended sediment concentration curve of a stream sampled 3 miles below the site of Dam "A" before the dam was placed in operation. It is noted that heaviest concentration of silt occurs at a discharge of approximately 3500 cu ft per sec, after which overbank flow commences, the average velocity of total discharge decreases, and the stream's silt concentration drops rather sharply.

The solid line in Fig. 1a shows sediment concentration at the same location after the dam became operative. This line depicts almost total removal of sediment load as a result of the desilting action of the reservoir.

Fig. 1b graphically illustrates the effect of Dam "A" on sediment loads at a location 87 miles downstream from the reservoir. Sediment concentration at this point before the dam was operative, shown by the dashed line, was similar to that existing near the

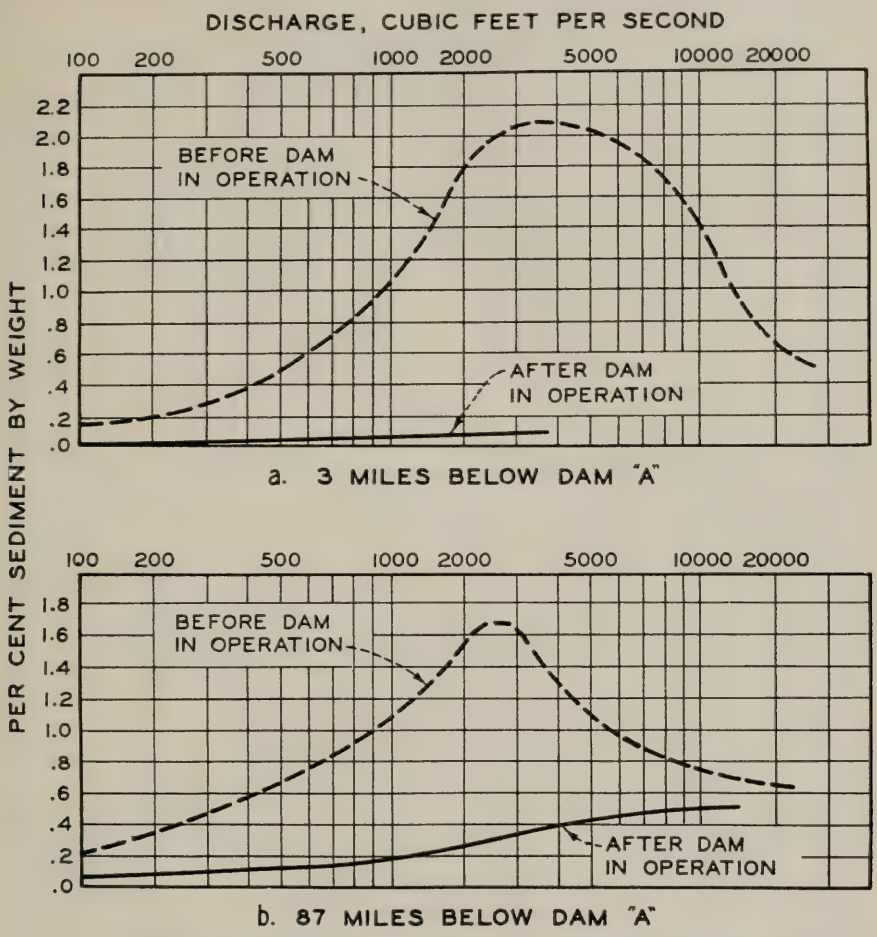

FIG. 1 SUSPENDED SEDIMENT CURVES, DAM "A"

dam site. The solid line, however, indicates that even during periods of relatively high discharge, the silt load has been lowered radically by reason of the dam's operation. At extremely high discharges, the "after" curve shows silt concentration more nearly approaching the amounts obtaining before the reservoir was placed in operation, indicating a recovery of near-normal silt load at the expense of accelerated erosion to stream bed and banks below the dam.

Thus, it appears obvious that the location of a reservoir upstream from a troublesome bank condition should enter into the considerations of a design for the placement or maintenance of bank protection below a dam. Systems dependent on the accretion of silt for their successful operation will not perform properly where a high percentage of sediment has been removed from the river. Such installations will, in fact, be more

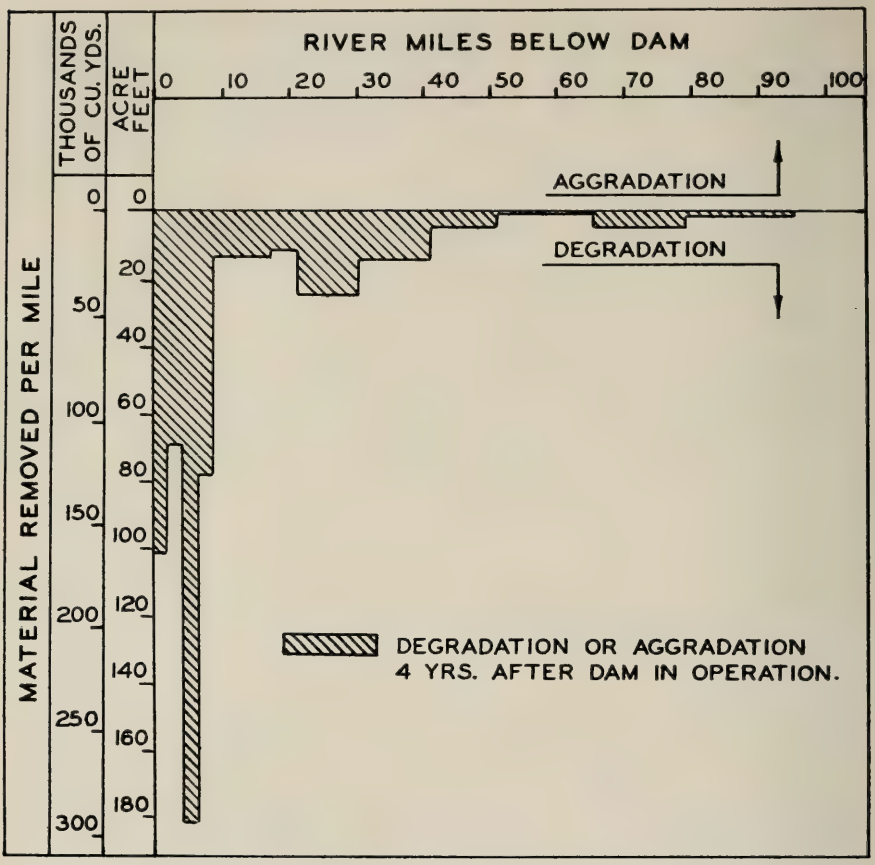

FIG. 2 DAM "A"

susceptible to damage or failure as a result of the stream's action in recovering its normal sediment load by attacking the river bed and banks until a natural balance is restored.

Degradation Below Reservoirs

In areas with adequate rainfall, desilting of a stream is often followed by degradation of the stream bed and banks for a considerable distance below a dam, and can well be a concern of those responsible for bank or scour protection.

Figs. 2, 3 and 4 graphically illustrate the extent of degradation below reservoirs on three different streams. While dissimilar in detail, a somewhat common pattern of material removal is evident in each case. Particularly interesting is Fig. 4, where quantities of material removed (or accreted) are separately designated. It is noted from these graphs that effects of the reservoir extend for 35 to 80 miles below the dam in the examples illustrated.

This pattern of degradation below dams may affect bank-control measures in many

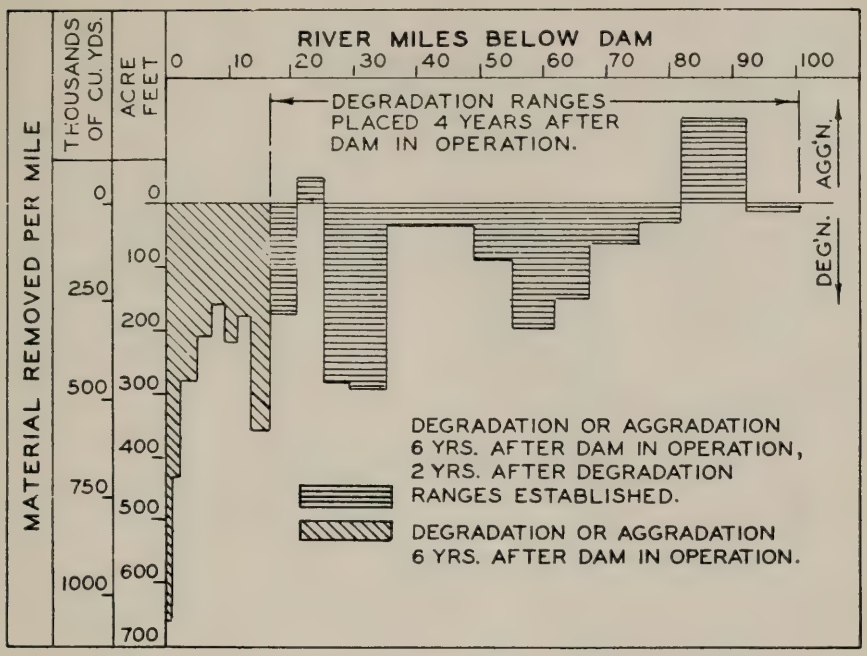

FIG. 3 DAM "B"

ways. Banks susceptible to caving may be expected to become more vulnerable to loss through the river's erosive action. Riprap bank lining may be under-cut by scour, with resulting settlement and loss of protection. Accelerated bank caving may progress above or below old jetty or riprap installations, lessening their stability. Accretion deposited through the years by jetties may again be picked up by "hungry" water, destroying the effectiveness of an installation and endangering its continued effectiveness or life.

Other Considerations

A further consideration of the effect of reservoirs on bank protection should include a brief discussion of the manner of their operation, especially those used primarily for flood control.

Reservoirs incorporating flood-control features are designed to store water in times of impending flood, after which it must be discharged as quickly as possible to provide storage capacity for a new emergency that may develop. The manner of discharging this stored water may vitally affect banks and bank protection for many miles downstream.

In one particularly wet season, for example, Dam "A" performed admirably in reducing flood crests in the river downstream from the reservoir. In order that its storage capacity could be restored for continued protection, however, water was released from the dam in quantities resulting in approximately three-quarters bankfull flow for a period of approximately 70 days. This flow, in spite of full control over discharges at the dam, resulted in varying degrees of rise and fall through some reaches of the stream

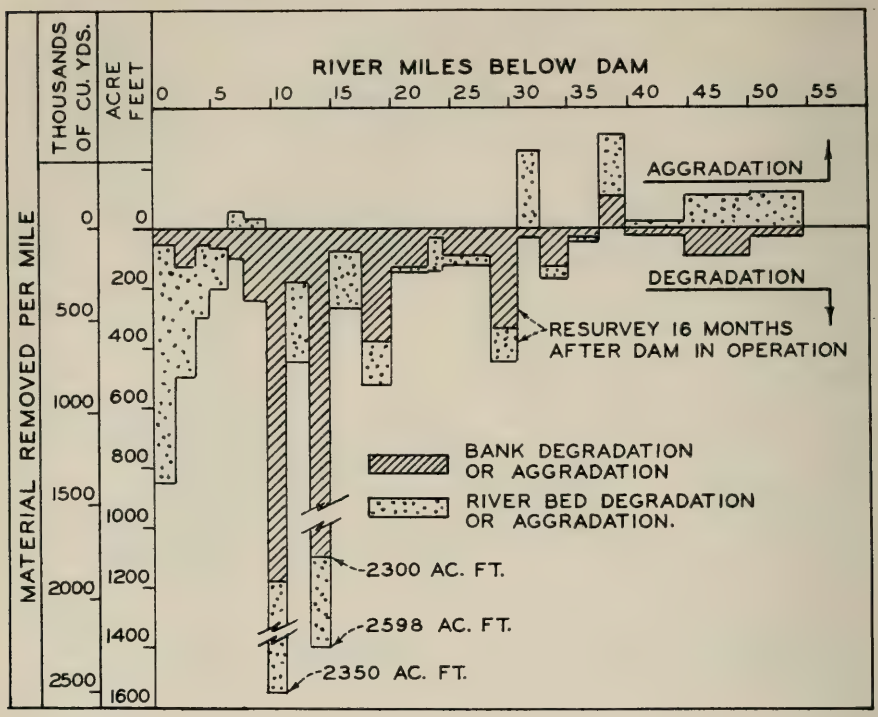

FIG. 4 DAM "C"

below the reservoir. During the prolonged high stages, its banks became permeated with water passing from stream to banks. During low stages, this flow was reversed, from banks to stream. Obviously, such reversal of flow carried with it varying amounts of bank material, which resulted in undercutting and sloughing of the river's banks. Thus, where long periods of time are required for discharging reservoir contents at near-bankful stream capacity below a dam, this surging or pumping effect on fluctuating stages tends to accelerate bank caving where soil conditions are favorable to such action.

By again referring to Fig. 4, it can be emphasized that degradation below dams results primarily in loss of bank material. Except for that reach immediately below the dam, desilting the stream has a much more pronounced effect on its banks than on its bed. With the ever increasing trend towards more and more reservoir construction in this country, the problem of controlling erosion of banks downstream becomes the problem of those who are charged with the responsibility of designing and providing good bank protection.

Conclusions

To summarize, where reservoirs are constructed on alluvial streams, bank cutting and channel widening can be expected downstream. Material removed from the channel will come chiefly from eroding banks, except that immediately below the dam such material will come from bed erosion. However, in irrigation areas where there is insufficient

outflow from the reservoir to keep the channel cleaned out, aggradation rather than degradation may occur below the dam.

Flow below the dam will tend to establish a condition of equilibrium by flattening slopes and widening channels. Locations requiring bank protection are likely to become more vulnerable to damage because of the desilting action of the reservoir.

Permeable bank protection will tend to produce reduced or insignificant quantities of deposition material, thus defeating the purpose for which they were installed.

Riprap bank lining may undercut and slump in desilted streams, and caving banks above riprap protection may increase the hazard of a stream's cutting in behind rock in place, endangering the whole installation.

Regulated outflow from a storage reservoir with attending fluctuation of stages downstream may result in heavy saturation of banks, followed by an accelerated tendency to slough and cave. Witness the fact that a stream with banks prone to cave badly under some conditions will withstand a violent midsummer flood with little or no additional bank loss, while spring fluctuations in stages on the same stream are often followed by extreme losses in bank material at that time.

Report on Assignment 4

Culverts

G. D. Mayor (chairman, subcommittee), W. T. Adams, J. G. Allan, R. A. Anderson, G. W. Deblin, T. F. de Capiteau, P. G. Martin, G. F. Nigh, C. W. Reeve, G. E. Shaw.

Your committee submits the following revised Specifications for Corrugated Metal Pipe for Subdrainage with the recommendation that they be adopted and published in the Manual, replacing the present specifications found on pages 1–4–11 and 1–4–12.

The major revisions are in the table and are intended to make the data therein agree with similar data in other standard perforated corrugated metal pipe specifications. The changes will provide adequate opening for the admission of ground water and provide a wider unperforated segment to carry the normal flow.

SPECIFICATIONS FOR CORRUGATED METAL PIPE FOR SUBDRAINAGE

1. Scope

These specifications cover corrugated metal pipe for use as underdrains. Unless otherwise specified, the pipe shall be perforated.

2. General Requirements

Except as herein modified, the pipe shall comply with the applicable sections of the AREA Specifications for Corrugated Metal Culverts, Part 4, this Chapter. The pipe may be either riveted pipe conforming to the specifications referred to, or it may be pipe having helical corrugations which are continuous from end to end of each length of pipe, with a continuous lock seam paralleling the corrugations, or a continuous welded longitudinal seam. The seam shall be so constructed as not to affect the shape or nominal diameter of the pipe, nor shall it reduce the strength of the pipe.

3. Corrugations

In pipe having a diameter of 10 in or less, the corrugations in helically corrugated pipe shall be not less than 1⅜ in or more than 1⅞ in center to center, measured at

right angles to the direction of the corrugations, and they shall have a depth of not less than ¼ in. In pipe having a diameter of more than 10 in and not more than 21 in, the corrugations in helically corrugated pipe shall be not less than 1⅞ in or more than 2¼ in center to center, measured at right angles to the direction of the corrugations, and they shall have a depth of not less than 7/16 in.

In riveted pipe with circumferential corrugations, the dimensions of the corrugations shall conform to the requirements of the AREA Specifications for Corrugated Metal Culverts, Part 4, this Chapter.

In helically corrugated pipe the angle between the direction of the corrugations and the longitudinal axis of the pipe shall be not less than 45 deg. In circumferentially corrugated pipe the angle between the direction of the corrugations and the longitudinal axis of the pipe shall be approximately 90 deg.

4. Perforations

Perforations shall be approximately ⅜ in. in diameter as measured on the finished pipe and shall be located in the inside crests of the corrugations. Perforations shall be in longitudinal rows spaced on approximately 1½-in centers in circumferentially corrugated pipe and on approximately 1-in centers in helically corrugated pipe, and extending to within 6 in of each end of each length of pipe.

Perforations may be made after the pipe is galvanized, and the rows shall be in two groups with half the number of rows on either side of an unperforated segment of approximately 90 deg.

The total number of rows of perforations and the width of the unperforated segment shall be as given in Table 1.

Table 1—Dimensions, Weights, Spacing and Perforations

Nominal Perforations		*Minimum Width of Unperforated Segment (Inches)*	*Weight per Linear Foot of Pipe Corrugated, Computed*			
			Helically Corrugated Pipe Gage Number		*Circumferentially Corrugated Pipe Gage Number*	
Internal Diameter (Inches)	*Total Number of Rows*		*18*	*16*	*18*	*16*
6	4	4.5	3.8	4.7	5.0	5.6
8	4	7.0	5.0	6.2	6.3	7.3
10	4	9.0	----------	7.6	----------	9.0
12	6	9.5	----------	9.9	----------	10.5
15	6	13.0	----------	12.4	----------	12.9
18	6	16.5	----------	14.8	----------	15.3
21	6	20.0	----------	17.2	----------	17.7

5. Gage and Weight

The average weight per linear foot of finished pipe, exclusive of end finish, shall not underrun the computed weight as given in Table 1 by more than 5 percent.

6. Coupling Bands

Field joints in corrugated metal pipe underdrains shall be made with galvanized band couplers of the same base metal as that used in the pipe. Band couplers shall have corrugations that mesh with the corrugations of the pipe. They shall be at least 7 in. in width and shall be of metal of the same gage number as the metal in the pipe.

If a one-piece band coupler is used, it shall be fastened with two galvanized bolts

with a minimum diameter of 3/8 in; if a two-piece coupler is used, it shall be fastened with four galvanized bolts with a minimum diameter of 3/8 in. Other equally effective methods for connecting the sections may be used if approved by the engineer.

Report on Assignment 5

Specifications for Pipelines for Conveying Flammable and Non-Flammable Substances

K. W. Schoeneberg (chairman, subcommittee), W. T. Adams, C. R. Bergman, L. H. Bond, J. G. Campbell, H. W. Clarke, T. F. de Capiteau, H. G. Johnson, J. W. Purdy, C. W. Reeve, R. W. Scott, A. J. Wegmann.

Your committee submits as information a progress report on its activities and studies relative to pipeline crossings under railroads and longitudinal or parallel occupancy by pipelines on railroad right-of-way.

As reported at both the 1957 and 1958 Conventions, study was being made of the present Specifications for Pipeline Crossings Under Railway Tracks as printed in the Manual, looking to making certain changes and revisions, as well as of the ever-growing problem of longitudinal or parallel occupancy by pipelines on railroad right-of-way. The first consideration of these matters pertained to flammable substances only. After further study a complete new set of specifications, or recommended practices, for pipelines for conveying flammable and non-flammable substances, Sec. A, for flammable substances, has been developed in which both subjects—pipeline crossings and longitudinal occupancy—have been combined. The new specifications are presented below for comment and criticism.

SPECIFICATIONS FOR PIPELINES FOR CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES

A. FOR FLAMMABLE SUBSTANCES

1. Scope

Pipelines included under these specifications are those installed to carry oil, gas, gasoline or other flammable or highly volatile substances under pressure.

2. General Requirements

a. Pipelines under railway tracks and across railway right-of-way shall be encased in a larger pipe or conduit called the casing pipe, as shown in Fig. 1.

The casing pipe may be omitted in the following locations:

(1) Under secondary tracks and industry spurs as approved by the railway company.

(2) On distribution lines in city streets where the stress in the pipe from internal pressure and external loads does not exceed 20 percent of the specified minimum yield strength of the pipe material.

Pipelines shall be installed under tracks by boring or jacking, if practicable.

Pipelines shall be located, where practicable, to cross tracks at approximately right angles thereto and shall not be placed within a culvert, under railway bridges, nor closer than 45 ft from any portion of any railway bridge, building or other important structure which might be injured by leakage from or failure of the pipeline.

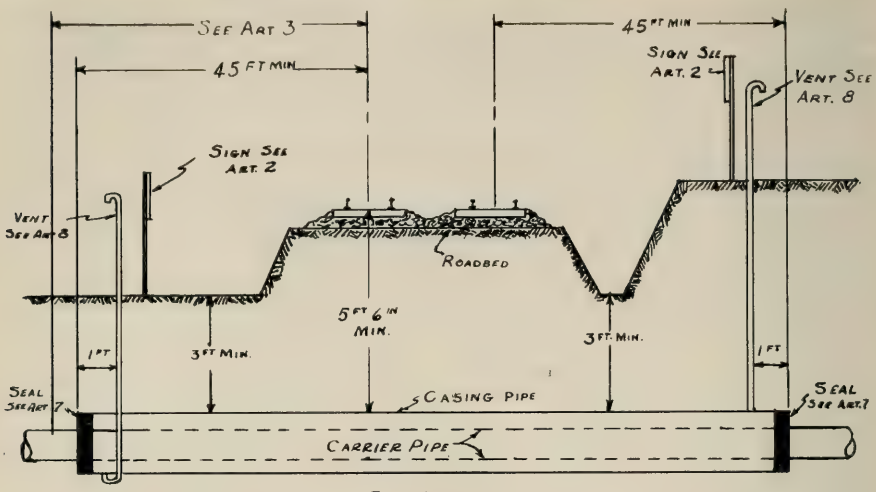

Fig. 1

b. Pipelines laid longitudinally on railway right-of-way shall be located as far as practicable from any tracks or other important structure. If located within 15 ft of the center line of any track or closer than 45 ft from the nearest point of any bridge, building or other important structure, the carrier pipe shall be encased.

c. Any replacement of a carrier pipe shall be considered a new installation, subject to the requirements of these specifications.

d. Where laws or orders of a competent public authority prescribe a higher degree of protection than specified herein, then the higher degree of protection so prescribed shall be deemed a part of these specifications.

e. Pipelines and casing pipe shall be suitably insulated from underground conduits carrying electric wires on railway right-of-way.

f. All pipelines, except in city streets, shall be prominently marked at the right-of-way (on both sides of track for undercrossings) by signs substantially worded thus:

"High Pressure ..... Main ..... ft under"

3. Carrier Pipe

Pipelines carrying oil, liquefied petroleum gas, natural or manufactured gas and other flammable products shall conform to the requirements of the current ASA B 31.4, Code for Oil Transportation Piping; ASA B 31.8, Code for Gas Transmission and Distribution Piping Systems and other applicable ASA codes, except that the maximum allowable stresses* for design shall not exceed the following percentages of the specified minimum yield strength of the pipe as defined in the ASA codes:

a. Steel pipe within a casing under railway tracks and across railway right-of-way:
   (1) Seventy-two percent for oil pipelines.
   (2) Fifty percent for pipelines carrying liquefied petroleum gas and other flammable liquids with low flash points.
   (3) Sixty percent for gas pipelines.

* If the maximum allowable stress in the carrier pipe on either side of the crossing is less than specified above, the carrier pipe at the crossing shall be designed for the same stress as the adjacent carrier pipe.

b. Steel pipe without a casing under secondary tracks and industry spurs:

(1) Fifty percent for oil pipelines.

(2) Forty percent for pipelines carrying liquefied petroleum gas and other flammable liquids with low flash points.

(3) Forty percent for gas pipelines.

c. Steel pipe laid longitudinally on railway right-of-way:

(1) Fifty percent for oil pipelines.

(2) Forty percent for pipelines carrying liquefied petroleum gas and other flammable liquids with low flash points.

(3) Forty percent for gas pipelines.

Note: The total stress in the pipe shall include the sum of the circumferential stress due to the maximum anticipated internal pressure plus the flexural ring stress due to external loads.

The minimum wall thickness for steel or wrought-iron carrier pipe shall be 0.2 in, except for pipelines 1½ in. in diameter and smaller operating at pressures less than 100 psi, where a thickness not less than that specified for extra-strong steel pipe by the U. S. Department of Commerce, National Bureau of Standards, may be used.

Requisites for carrier-line pipe under railway tracks shall apply for a minimum distance of 100 ft from (measured at right angles) the center line of the outside tracks or 40 ft beyond the ends of the casing (when casing is required), whichever is greater.

The pipe shall be laid with sufficient slack so that it is not in tension.

4. Casing Pipe

The casing pipe and joints shall be of metal and of leakproof construction, capable of withstanding railway loading.

Wall Thickness For Steel Casing Pipe For E 72 Loading (Including Impact)

Minimum Thickness, Inches	*Diameter of Pipe, Inches*	*Minimum Thickness, Inches*	*Diameter of Pipe, Inches*
0.250	Up to 16	0.406	28
0.281	18	0.438	30
0.312	20	0.500	32 and 34
0.344	22	0.562	36 and 38
0.375	24 and 26	0.625	40 and 42

Steel pipe to have a minimum yield of strength of 35,000 psi.

Where the installation of the casing is by boring or jacking and cathodic protection is not provided, or when bare casing is used, the wall thickness shown above shall be increased to the nearest standard size which is a minimum of 0.063 in greater than the thickness shown in the table.

Cast-iron pipe may be used as casing provided the method of installation is by open trench. Cast-iron pipe used as casing shall conform to American Standards Association Specification A21. The pipe shall be of the mechanical joint type or plain-end pipe with compression-type couplings. The strength of cast-iron pipe to sustain external loads shall be computed in accordance with ASA A21.1 "Manual for the Computation of Strength

and Thickness of Cast-Iron Pipe". Pit-cast pipe may be used up to 20 in diameter. Centrifugal-cast pipe shall be used for installations over 20-in diameter.

The inside diameter of the casing pipe shall be such as to allow the carrier pipe to be removed subsequently without disturbing the casing pipe. All supports, insulators or centering devices for the carrier pipe within a casing under railroad tracks shall be so designed and constructed that, and allowing for a minimum free vertical deflection of the casing pipe of 3 percent of its diameter, no loads from the roadbed, track, traffic or casing pipe itself are transmitted to the carrier pipe.

Casing pipe under railway tracks and across railway right-of-way shall extend a minimum distance of 45 ft on each side from (measured at right angles to) the center line of the outside track. If additional tracks are constructed in the future, the casing shall be extended correspondingly.

5. Construction

The casing pipe shall be so constructed as to prevent the leakage of any matter from the casing throughout its length, except at the ends of the casing where the ends are left open, or through vent pipes when the ends of the casing are sealed. The casing shall be so installed as to prevent the formation of a waterway under the railway, and with an even bearing throughout its length, and shall slope to one end (except in the case of longitudinal occupancy).

In the case of open-trench methods, all backfilling shall comply with Art. 2. Backfill, of Installation of Pipe Culverts, Part 4, this Chapter.

Bored or jacked installations shall have a bored hole diameter essentially the same diameter as the outside diameter of the casing pipe plus the thickness of the protective coating. If voids should develop or if the bored hole diameter is greater than the outside diameter of the pipeline or casing (including coating) by more than 1 in, remedial measures as approved by the chief engineer of the railway company shall be taken. Boring operations shall not be stopped if such stoppage would be detrimental to the railway.

Tunnelling operations shall be conducted as approved by the chief engineer of the railway company. If voids are caused by the tunnelling operations, they shall be filled by pressure grouting or by other approved methods which will provide an equivalent degree of support.

Where the casing and/or carrier pipe is cathodically protected, the railway company shall be notified and suitable test made to insure that other railway structures and facilities are adequately protected from the cathodic current in accordance with the recommendations of the Report of Correlating Committee on Cathodic Protection, published in July 1951 by the National Association of Corrosion Engineers.

6. Testing

Proof testing of carrier pipe shall be in accordance with the current specifications of the ASA Code B31.4 or B31.8 for the applicable class location but not less than Class 3 or 4 in the case of main lines or Class 2 for all other tracks.

7. Seals

Where the ends of the casing are below ground they shall be suitably sealed to the outside of the carrier pipe.

Where the ends of the casing are at or above the ground surface and above the high-water level, they may be left open, provided drainage is afforded in such manner that leakage will be conducted away from railway tracks or structures. Where proper drainage is not provided, the ends of the casing shall be sealed.

8. Vents

The casing pipe, when sealed, shall be properly vented in accordance with the best engineering practice, and vent pipes shall be of sufficient diameter, but in no case less than 2 in.

The vent pipe, or pipes, shall extend not less than 4 ft above the ground surface. The top of the vent pipe shall be fitted with a down-turned elbow properly screened. Vents in locations subject to high water shall be extended above the maximum elevation of the high water and shall be supported and protected in a manner that meets the approval of the chief engineer of the railway company.

The vent pipes shall be at least 4 ft (vertically) from aerial electric wires.

9. Depth of Installation

a. Casing pipe under railway tracks and across railway right-of-way shall be buried not less than 5½ ft from the base of the railway rail to the top of the casing at its closest point. On other portions of the right-of-way where the casing is not directly beneath any track, the depth from ground surface and from the bottoms of ditches to the top of the casing shall be not less than 3 ft.

b. Carrier pipe installed under secondary tracks or industry spurs without benefit of casing shall be buried not less than 4½ ft from the base of the railway rail to the top of the pipe at its closest point nor less than 3 ft from the ground surface or from the bottoms of ditches.

c. Pipeline laid longitudinally on railway right-of-way shall be buried not less than 4 ft from the ground surface to the top of the pipe, unless the pipeline is laid on top of a cut, where the bury may be 2 ft.

10. Shut-Off Valves

Accessible emergency shut-off valves shall be installed within effective distances on each side of the railway as mutually agreed to by the railway company and the pipeline company. Where pipelines are provided with automatic control stations at locations and within distances approved by the railway company, no additional valves shall be required.

11. Approval of Plans

Plans for a proposed installation shall be submitted to and meet the approval of the chief engineer of the railway company before construction is begun. The plans shall be drawn to scale showing the relation of the proposed pipeline to the railway tracks, angle of crossing (if any), location of valves, railway survey stations, right-of-way lines and general layout of tracks and railway facilities. The plans should also show a cross section (or sections) from a field survey, showing the pipe in relation to the actual profile of the ground and tracks. If open cutting or tunnelling is necessary, the details of the sheeting and the method of supporting the tracks or driving the tunnel shall be shown.

The execution of the work on railway right-of-way, including the supporting of tracks, shall be subject to the inspection and direction of the chief engineer of the railway company.

In addition to the above, the plans should contain the following data:

	Carrier Pipe	*Casing Pipe*
Contents to be handled	.....	.....
Outside diameter	.....	.....
Material	.....	.....
Specification and grade	.....	.....

	Carrier Pipe	*Casing Pipe*
Weight per lineal foot		
Actual working pressure		
Test pressure		
Type of joint		
Coating		
Method of installation		
Vents: Number ..... Size .... Hgt. above ground		
Seals: Both Ends ..... One End		
Bury: Base of rail to top of casing.....ft.....in.		
Bury: (Not beneath tracks).....ft.....in.		
Bury: (Roadway ditches).....ft.....in.		
Cathodic protection		

Report on Assignment 6

Roadway: Formation and Protection

(a) Roadbed Stabilization

(b) Slope Protection by Use of Additives

(c) Performance of Filter Materials in Subdrains

(d) Gypsum Treatment of Subgrade to Improve Track Drainage

F. N. Beighley (chairman, subcommittee), T. W. Creighton, B. H. Crosland, H. O. Ireland, W. G. Murphy, G. W. Payne, A. J. Pacelli, G. S. Sowers, C. E. Stoecker.

Your committee reports this year on Assignments (a) and (c) only. The report on Assignment (a) submitted as information, covers "Investigation of Landslides for Planning Remedial Measures," prepared by Ralph B. Peck and Don U. Deere of the University of Illinois.

The report on Assignment (c), also submitted as information, covers "Performance of Filter Materials." The report was prepared by John C. Guillou, also of the University of Illinois.

The work represented by these reports is part of the research sponsored by the committee and administered by the Research Department, AAR, under the direction of G. M. Magee, director of engineering research, and supervised by Rockwell Smith, research engineer roadway. The research has been performed at the University under a cooperative agreement with that institution. Professors Peck and Guillou are in charge for the university.

Report on Assignment 6 (a)

Investigation of Landslides for Planning Remedial Measures

By Ralph B. Peck and Don U. Deere*

Introduction

Slides of hillsides and cut slopes are not uncommon occurrences along railroad lines. Frequently they threaten the safety of operation; often they disrupt traffic. Once a new slide has started or an old one has renewed activity, remedial measures must be

* Respectively, professor of foundation engineering, and professor of civil engineering and of geology, University of Illinois.

planned. However, the external appearance of a slide rarely reveals without question the causes of the movement. Many slides with similar surficial features have widely different causes. Hence, intelligent planning of remedial measures requires investigation into the significant factors that can rarely be ascertained on the basis of field inspection alone.

Many slides of present concern are revivals of old movements. Even prehistoric landslides are commonly the seats of new disturbances. It is often of prime importance to realize that the causes of the present movements and, as a consequence, the appropriate remedial measures, may not be at all similar to the causes of the original movements. Quite incorrect inferences can be drawn from unwarranted concentration on the factors associated with the initial instability.

Nevertheless, one of the first steps in the investigation of a slide is the collection and organization of all the available history of movement in the area, together with other data that may seem pertinent. In an old slide area, the files of the railroad may contain a remarkable quantity of useful information about the movements, the attempted remedial measures, the possible influence of the weather, and many other matters. A digest of such information from the files, supplemented by the statements and observations of roadmasters, section foremen and others intimately acquainted with the line, constitutes the first step in the investigation.

Boring Program

Unless the slide should more properly be classified as a rock fall and the geological conditions are obvious, it will be necessary to set up a program of test borings. These serve the purpose of establishing the soil profile, of providing samples of representative materials suitable for physical tests, and of establishing groundwater conditions.

The most suitable type of boring depends somewhat on local conditions. For the majority of sites the standard-penetration-test boring procedure[1] is likely to be most appropriate. The principal advantages are the ability to get satisfactory samples from borings in fairly inaccessible locations, the approximate determination of the consistency or density of the soil by means of the penetration test, and usually the possibility of getting at least preliminary information concerning the groundwater levels and permeability. The samples are discontinuous, but if continuous samples prove to be desirable, they can be obtained with the same equipment in thin-walled tubing.[2] Finally, borings of this type are the least expensive from which satisfactory data can be obtained.

The number and depth of borings cannot be established without knowledge of specific site conditions. On small slides at least one boring should be made through the slide material and well into the undisturbed material beneath. It is usually desirable to have at least one boring in the undisturbed formations just above the upper escarpment of the slide. On large or complex slides several sets of borings, arranged on typical cross sections, may be advisable.

Samples from the borings should be described accurately in a soil mechanics laboratory and subjected to pertinent classification tests. If the soils are cohesive, the strength should be determined, at least by means of the simple and inexpensive unconfined compression test. In some instances, the strength can best be investigated by in-place vane tests[3] or even more refined procedures.

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[1] The procedure has been described in detail in several publications, including the AREA Manual, Chapter 1.

[2] See Area Manual, Chapter 1, Specifications for Test Borings.

[3] Vane Shear Testing of Soils. ASTM Technical Publ. 193 (1957).

Borings are not ordinarily adequate for detection of the surface or zone of sliding. More positive information is furnished by tiltmeter surveys as described subsequently. However, as the borings may provide holes in which the tiltmeters can be installed, or in which devices for observing the water level can be established, it is apparent that the most efficient investigational program requires the close supervision of an engineer who can decide, as the borings progress, on the most appropriate future use of the drill holes.

Groundwater Observations

Each boring should, if practicable, be converted into a standpipe for observation of groundwater levels. If the boring terminates in pervious materials the casing may be left in the hole to serve as the standpipe. In rather impervious soils or under complex subsurface conditions the simple standpipes may have to be supplemented or replaced by means of more refined equipment. In particular, where deposits of varved clay are encountered, or deposits of clay containing strata of sand or silt, the water levels may differ in different pervious layers. It is then necessary to place a porous unit with an appropriate measuring device opposite each pervious layer in which the water levels are desired, and to seal the unit with clay or plastic against communication with all other pervious layers. The porous unit may often be an ordinary well point or, in quite impervious soils or for long-time observations, a filter tube of ceramic material. Such installations may require great care and expert supervision but, where groundwater conditions are complex, they are indispensable.[4, 5] All too often entirely incorrect conclusions have been drawn concerning the mechanism of slides in which the groundwater level was assumed to be at a single elevation on the basis of observations in a single observation well interconnecting all the pervious zones.

An example of an installation to investigate the levels in several layers is illustrated in Fig. 1. At the site of this landslide the ground water level was shown by a shallow boring to vary from 6 to 12 ft below the surface. When the deep layer of dense fine sand was encountered in a later boring, it was suspected that artesian water might be present in the sand. Five piezometers were installed at various depths in a single drill hole, and after two or three days the water levels reached equilibrium as shown in the figure. To the surprise of the investigators the deep layer of sand had no artesian water pressure but was acting as a drain for the perched water table in the upper sand and silt zone. Much of the water apparently flowed downward through vertical joints in the varved clay.

Geometry of Slide

The engineer must determine the shape and dimensions of the sliding mass; otherwise no rational analysis can be made.

The first requirement is a reasonably accurate topographic map, on the basis of which cross sections of the upper surface of the slide can be prepared. The topography can be established by ground survey or, in many instances, preferably by means of airphotos. The airphotos are also advantageous in disclosing many details of the slide that may escape detection or may be difficult to recognize from the ground. Stereo-pairs are especially valuable.[6]

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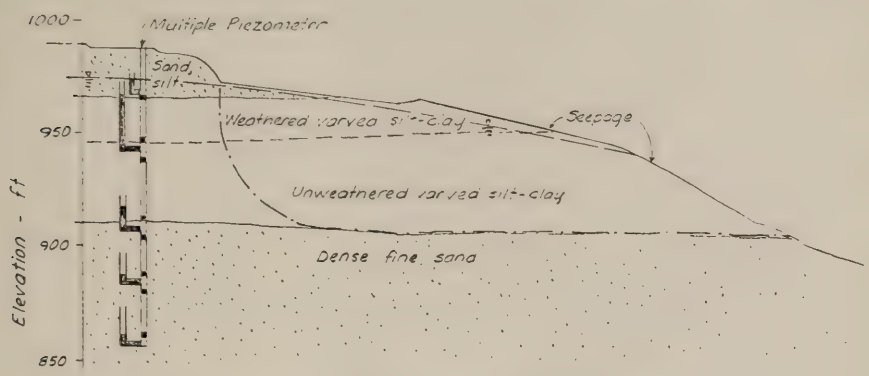
[4] Details and instructions for installing ceramic-tube piezometers are given by A. Casagrande, Jour. Boston Soc. C.E., April 1949 and reprinted in Contributions to Soil Mechanics 1941-1953, Boston Soc. C.E., p. 198-205.

[5] Lambe, T. W., "Sealing the Casagrande Piezometer", Civil Engineering, April, 1959, p. 66.

[6] Stereo-pairs of airphotos can be obtained for much of the U. S. and Canada. Indexes of airphoto coverage are available from U. S. Dept. of Agriculture, Commodity Stabilization Service, Performance Div., 2505 Parleys Way, Salt Lake City 9, Utah, or Washington 25, D. C.



DETERMINATION OF MULTIPLE WATER LEVELS
TAUNTON SLIDE
FIG. 1

By means of airphotos and ground inspection, the outline of the slide should be drawn on the topographic map, together with the position of all cracks, bulges, springs or seepages or similar features.

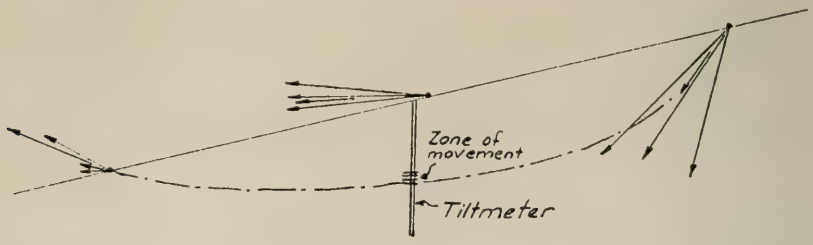
Finally, the position of the surface of sliding must be established with reasonable accuracy. In particular the maximum depth of the slide is significant.

In some instances the surface of sliding can be determined from a study of the escarpments at the head of the slide, the bulges at the toe, and the geology of the locale as supplemented by data from the test borings Where loose or weak materials rest above bedrock or hard material with its upper surface at a consistent elevation, there may be little doubt as to the lower boundary of the slide. In some cases a study of the surficial movements may assist in the determination of the shape of the surface of sliding, as the inclination of this surface below a point on the ground surface is likely to be nearly parallel to the direction of the movement at the ground surface (see Fig. 2).

Very often, however, direct observations may be required to establish the position of the surface of sliding. The most effective instrument in current use for this purpose is the slope indicator, a form of tiltmeter developed by S. D. Wilson.[7] A tiltmeter installation includes placing a plastic tube in a drill hole and packing the space between tube and surrounding soil with sand or thixotropic drilling mud. The tube has precisely machined grooves on the inside to guide the instrument proper which is lowered into the hole and which indicates electrically its deviation from the vertical at successive depths. The instrument is of high sensitivity. Hence, if even small displacements occur between two successive sets of readings, the position and magnitude of the displacements can be determined with great accuracy.

Fig. 3 represents a striking example of the manner in which the zone of movement was located by tiltmeter readings taken one week apart. It should be noted that above a depth of 50 ft the ground is moving essentially as a block. At some landslides the tiltmeter readings have shown the movement to be limited to a zone even less than a foot in thickness. Less commonly the movement is found to be distributed throughout the sliding mass.

[7] Wilson, S. D. and Hancock, C. W., Horizontal Displacement of Clay Foundations. Proc. First Pan-American Conference on Soil Mechanics and Foundations, Mexico City, 1959.



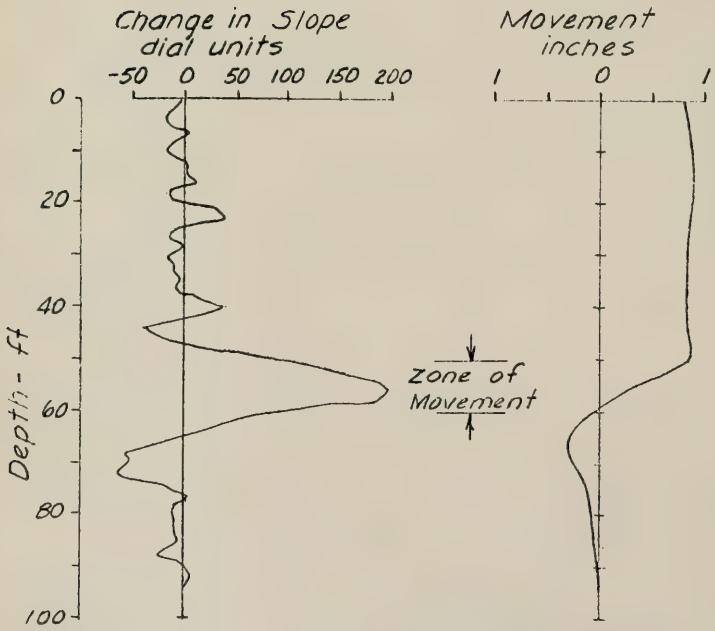
Scales:

Movement vectors ⟷ 1 ft per 100 days

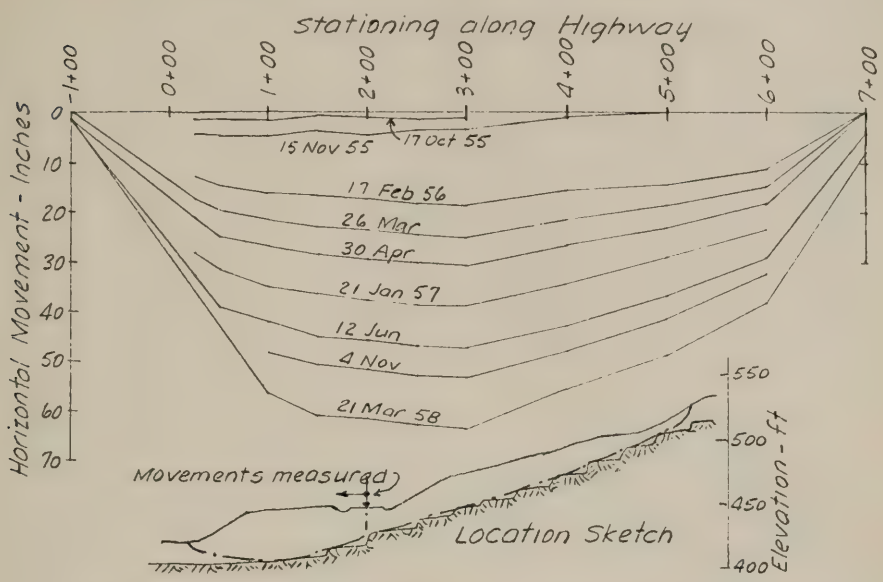
Distances ⟷ 100 ft

Movements measured at four locations at each level

RATE AND DIRECTION OF SURFACE MOVEMENTS
WAIOMAO SLIDE
FIG. 2



MOVEMENT OF TILTMETER CASING IN ONE WEEK
WAIOMAO SLIDE
FIG. 3



HORIZONTAL MOVEMENT OF BASE LINE ON HIGHWAY
NEW ALBANY SLIDE
FIG. 4

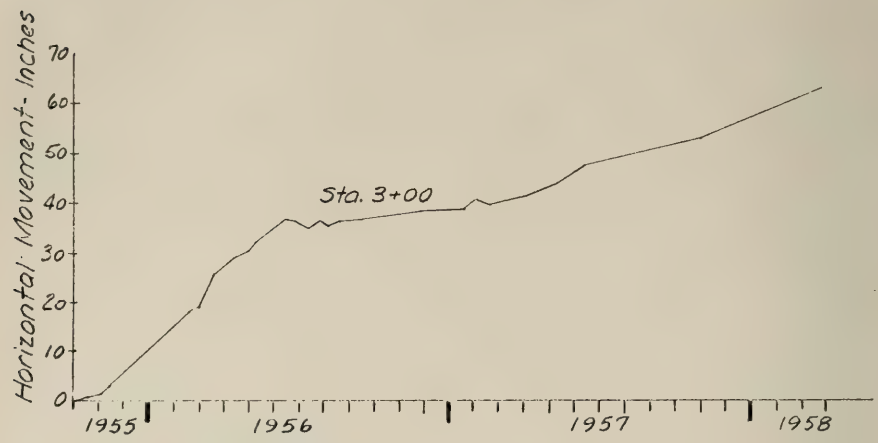
In Fig. 2 the zone of movement determined by the tiltmeter is shown as well as the surface of sliding which was reconstructed using this information. The movement vectors, which were determined at the ground surface by horizontal and vertical measurements on hubs, are also plotted.

Rate of Movement

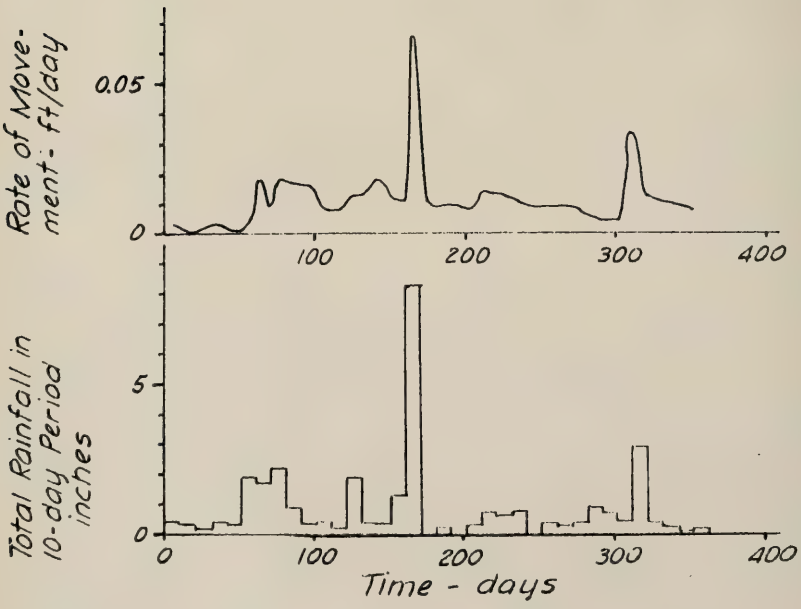
It is extremely beneficial to establish the rate of movement of slides. From the measurement of the rate it is possible to establish the boundaries of the sliding mass, to note the growth of the slides or any increase or decrease in activity of various portions of the slide, to determine any seasonal variation in activity, and to observe the effectiveness of remedial treatment.

Referring again to Fig. 2 it will be noted that the vertical components of movement are not everywhere even approximately equal. Near the center line of the slide they are negligible. Therfore, vertical measurements are not always sensitive indicators of slide activity except possibly at the head of a slide. The horizontal component is usually the more reliable index of rate of movement.

The measurement of the horizontal offset of the plastic casing in successive tiltmeter observations is one way in which the rate of movement may be determined. Of more general value, however, is the observation of the horizontal offset of stations which have been established on about 100- or 200-ft centers along a baseline located across the slide area on a line roughly parallel to and midway between the toe and head of the slide. The ends of the baseline must necessarily be sufficiently distant from the slide area so as not to be involved in the movement. Fig. 4 illustrates the accumulative horizontal



HORIZONTAL MOVEMENT vs TIME, NEW ALBANY SLIDE
FIG. 5



RATE OF MOVEMENT vs RAINFALL, WAIOMAO SLIDE
FIG. 6

movement of several stations at various periods of time for a large landslide. The progressive growth of the slide between Sta. 4 + 00 to Sta. 7 + 00 between the dates of November 15, 1955 and March 21, 1958 is striking. It is also apparent that the end of the baseline, Sta. 7 + 00, was not sufficiently far from the slide, as it also was affected by the movement. The displacement of Sta. 3 + 00 is plotted against time in Fig. 5. The time of major activity of the slide is well illustrated by this type of plot. Horizontal movements as small as ¼ in per month may be readily detected by careful field surveying.

It is generally recognized that slides become more active during periods of rainfall. Plots of rate of movement versus amount of rainfall, such as shown in Fig. 6, almost invariably bear this out, although under certain geological conditions there may be a time lag of several days or even weeks. Similar plots may be made for rate of movement versus piezometric levels. Such plots are more useful than those relating movement and rainfall, because they may permit an estimate of the amount the water table must be lowered to achieve stability.[8]

Slide Analysis and Corrective Measures

It is not the purpose of this paper to discuss the details of slide analysis or corrective measures.[9] However, no analysis can be made unless the pertinent factors concerning the slide are known. These include the topography and shape of the sliding mass, the ground-water conditions, the strength and arrangement of the various subsoil strata, and the effect of varying piezometric levels on the rate of movement of the slide.

[8] Terzaghi, K., Mechanism of Landslides, Berkey Volume, Application of Geology to Engineering Practice, Geological Society of America (1950) p. 120.

[9] For discussion of these subjects see "Landslides and Engineering Practice, Highway Research Board Special Report 29 (1958), Chaps. 7, 8 and 9.

Report on Assignment 6 (c)

First Progress Report on Performance of Filter Materials

By John C. Guillou[1]

Introduction

The cooperative research program "Performance of Filter Materials" was activated July 1, 1958. The purpose of the program is to evaluate the requirements of filter materials around underground perforated or open-joint drains and to develop definite design information for field conditions.

Activity on the project has been at a more deliberate pace than originally planned because of financial retrenchment. However, since specific information is available from different phases of the program, it is believed that the material should be presented at this time. The project is sponsored by the Association of American Railroads and is being conducted in conjunction with Committee 1—Roadway and Ballast, of the AREA.

The report is organized along lines of the research activity, and major findings of the separate phases are presented. Since the findings are considered to be of preliminary nature, no definite design proposals are presented.

Major findings may be summarized as follows:

1. Study of existing literature and design procedures indicates that the use of concrete sand around a perforated drain pipe will provide a satisfactory filter.

[1] Research associate professor hydraulic engineering, University of Illinois.

Criteria used to judge the design and performance of filters are grossly qualitative. Specific data regarding filter design and operation are virtually nonexistent.

2. Experimental work indicates that there is an extremely wide variation in the intercepting ability of coated and uncoated perforated corrugated metal pipe. For example, considering the commercially available samples used in the laboratory, under a head of 0.5 ft the capacity of the plain pipe is 0.029 cu ft per sec per ft of length while the capacity of the coated pipe is 0.0009 cu ft per sec per ft.
3. Sieve analysis of filter material and material washed into the laboratory drain pipe indicates that virtually no sorting, or selection of material, occurs at the drain pipe perforation. If this finding is further substantiated, it must be concluded that filter material is excluded from the pipe by arch action in the filter material and not by bridging of major-size filter particles.
4. The results of a questionnaire study indicate that over 70 percent of the filter drains that are being installed use perforated corrugated metal pipe, and that over 60 percent of the filter material is crushed stone or washed gravel.

Summary of Existing Literature

The highlights of available information are contained in three separate references. The first of these is a paper prepared in 1940 by G. E. Bertram relative to an experimental investigation of the efficiency of protective filters. Mr. Bertram further developed and standardized the findings of Karl Terzaghi (circa 1920) and presented several conclusions relative to the importance of "minimum critical ratio" in the design of filter blankets. Minimum critical ratio is defined as the ratio of the 15-percent-size material in the filter to the 15-percent-size material in the native ground. Bertram has indicated that the limit of filter stability is obtained when the "critical ratio" is approximately 9.0.

In 1941 the Corps of Engineers, at the Waterways Experiment Station Laboratory in Vicksburg, Miss., investigated requirements of filters when specifically applied to an under-drain system. The Corps work indicates that the "critical ratio" as developed by Bertram may be reduced to 5 without undue instability, that the filter should be compacted, that holes in perforated pipes should be located near the bottom of the pipe, and that the pipe holes should be small.

Three years after the Corps of Engineers work, Armco performed a series of relatively extensive tests to re-evaluate the design of their perforated sub-drain pipe. These studies were conducted after thorough study of the Vicksburg information. The result of the Armco tests was the resizing of the perforated holes to $\frac{5}{16}$ in diameter and the location of the holes on either side of an unperforated invert at an angle of 22½ deg from the horizontal.

Following the Armco tests, the American Association of State Highway Officials and American Railway Engineering Association specifications detailing the size and location of holes in perforated drain pipes were prepared.

Based upon the Vicksburg and Armco tests, the Corps of Engineers has stated in its "Engineering Manual for Military Construction", Part XIII, Chapter 2, as follows:

> "Experience has shown that for the majority of fine, sandy, and silty soils a concrete sand forms a satisfactory filter, i.e., meets the design requirements. When such sands contain a sufficient amount of fine gravel sizes, and for pipes with small openings, they are safe against infiltration into the pipe."

The pertinent criteria for sizing of filter materials are summarized as follows:

1. To prevent movement of filter material into the drain pipe, the ratio of the 85-percent size of filter material to the size of opening in the pipe should be equal to, or less than, 1.0 for circular holes, and equal to, or less than, 1.2 for slots.
2. To prevent movement of particles from the native material into the filter, the ratio of the 15-percent size of filter material to the 85-percent size of base material should be equal to, or less than, 5.0; and the ratio of the 50-percent sizes of filter and native materials should be equal to, or less than, 25.
3. To insure adequate drainage by the filter material the ratio of the 15-percent sizes of filter to native material should be equal to, or greater than, 5.

One of the most recent references pertaining to filter drains is Bulletin No. 209, of the Highway Research Board which was published in 1959. This report, entitled "Subsurface Drainage for Highways and Airports", includes virtually the same filter drain criteria as the Engineering Manual.

Theoretical Development

Present day subsurface drains are composed of two principal parts—the filter material and the drainage pipe. The function of the filter material is to transmit intercepted water to the drainage pipe and to exclude from the intercepted flow particles of native soil, or base material. The drainage pipe serves the dual function of removing intercepted water from the filter and of carrying it to a point of disposal.

The present phase of the research program is principally concerned with the ability of the drain pipe to receive water from the filter material. This interest includes both the ability to intercept water and the ability to maintain a stable filter.

Accepted theory concerning the flow of ground water is based upon the works of Hagen[(1)]* and Poiseuille[(2)] who first (1839 and 1840, respectively) determined that the rate of flow through capillary tubes varied directly with the hydraulic gradient or pressure gradient. In 1856 Darcy published his well known paper on the Dijon water supply[(3)], which verified the earlier findings of Hagen and Poiseuille. Darcy expressed the law governing the laminar flow of water through a column of permeable material as

$$v = P\frac{h}{l} \qquad (1)$$

where v is the velocity of flow, P is the permeability of the material, h is the difference in head at two sections of the vertical column, and l is the distance between the two sections. It should be noted that the equation applies to laminar flow and not to turbulent flow where velocities are sufficiently high to cause eddy losses behind particles.

The Darcy law (Eq. 1) may be combined with the continuity equation and applied to the horizontal flow of ground water in a unit width, as follows

$$q = v\,A = P\,I\,A = P\left(\frac{dy}{dx}\right)y \qquad (2)$$

where $\frac{dy}{dx}$ is the slope of the gradient and y is the depth of flow. Application of Eq. 2 to the conditions set forth in Fig. 1 would yield the flow per foot of length of the drain, above base z, at the point x,y.

* Numbers in parentheses refer to reference in the Bibliography at the end of this report.

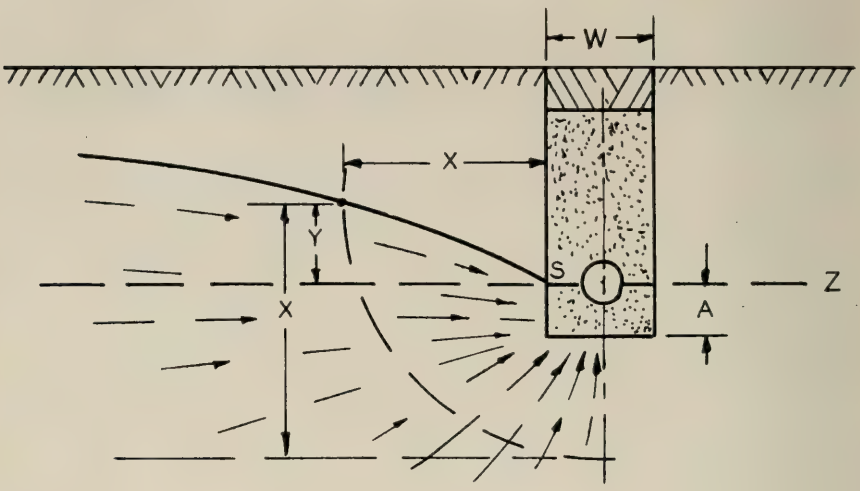


FIGURE 1 - IDEALIZED FLOW TO FILTER DRAIN

Since, in actuality, underdrains receive flow from above and below base z it is usually assumed that the flow is contributed through a cylindrical surface with unit length along the pipe, and with radius x. Under this condition Eq. 2 becomes

$$Q = P\left(\frac{dy}{dx}\right)\left(\frac{\pi x}{2}\right) \qquad (3)$$

Eq. 3 is only an approximation of true conditions for two significant reasons.

1. It is assumed that the surface slope $\frac{dy}{dx}$ is the gradient throughout the aquifer.
2. The use of the cylindrical area in the continuity equation assumes that the flow paths are normal to surface of the cylinder. As indicated on Fig. 1 this is not the case.

The limitations of Eq. 3 may be partially mitigated by the application of a flow-net procedure where actual streamlines of flow are developed for the control boundaries. In the case of the filter drain the control boundaries are the free-water surface, $x - s$; the center line of the drain, assuming symmetrical flow conditions; and the area through which the flow enters the filter, $a + \frac{w}{2}$. Equipotential lines are developed in the process of constructing the flow net, and the resulting pattern is a series of small flow prisms with varying areas and gradients. The hydraulic gradient for unit head, i, is found by dividing the number of equipotential divisions, normal to a flow path, N_1, by the number of flow prisms, N_2, within the flow path. Thus

$$i = \frac{N_1}{N_2}$$

Use of this gradient, with the appropriate head, y, in the Darcy equation yields

$$q = P\,y\left(\frac{N_1}{N_2}\right) \qquad (4)$$

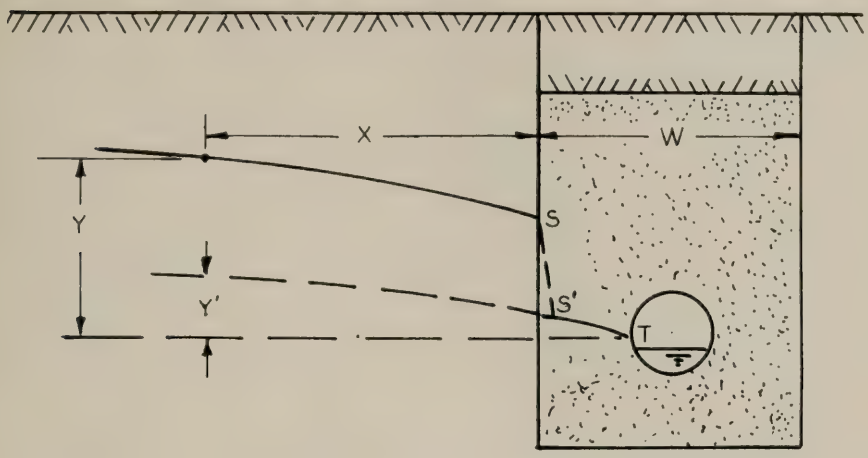


FIGURE 2 - IDEALIZED FLOW THROUGH FILTER

This equation represents the best available evaluation of flow into filter drains. Solution of the equation requires the construction of a flow net, and assumption of a homogeneous deep native material, or aquifer, and definite knowledge of the permeability of the material being drained. Obviously, these conditions somewhat exceed the design case.

Use of Eq. 4 to determine the required size of drain pipe requires that the rate of flow through the native material must equal the flow through the perforations in the pipe.

The preceding development is based upon a native free water surface which is in contact with the water surface within the filter material. Consideration of Fig. 2 indicates that this is only true for the static condition of a lowered water table in the natural ground or for the condition of back water from the drain pipe. Since flow in the ground is equal to flow in the filter, Eq. 2 may be written as

$$P_1 I_1 A_1 = P_2 I_2 A_2$$

where the subscripts 1 and 2 refer to the material being drained and the filter material, respectively. If the ratio of filter permeability to ground permeability is r, then the preceding equation may be expressed as

$$I_1 = r\, I_2 \left(\frac{A_2}{A_1}\right)$$

Considering that the interface between the ground and the filter areas are equal, it follows that at this point the gradient in the ground must be equal to the product of the permeability ratio and the gradient in the filter material.

Examination of Fig. 2 indicates that only when the ground water level is in its lowest position (available fall $= y'$), or when there is backwater from the pipe, can the area

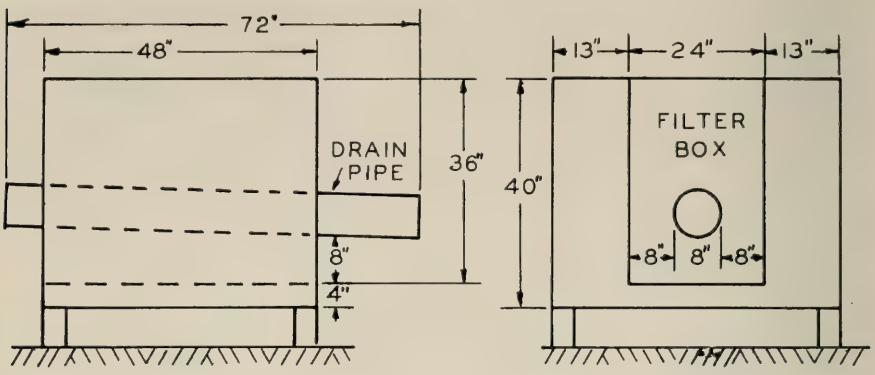


FIGURE 3 - SKETCH OF EXPERIMENTAL TEST TANK

of flow from the natural ground be equal to the area of flow into the filter. In the usual case the surface profile must follow the path x—s—s′—t.

Because of the preceding considerations it now appears that a very large percentage of the filter material that is used around perforated drains is of little real value. For example, if the preceding development is verified in the laboratory, it is apparent that:

1. Filter material above "s" (Fig. 2) is unnecessary.
2. Filter material below the bottom of the pipe is of little value since it serves only to distribute flow in the filter.
3. The width of trench, w, would seldom need to exceed the pipe diameter, D, by more than about one diameter.

Experimental Activity

The experimental apparatus was designed to permit laboratory evaluation of the performance of filters using concrete sand. Since the initial program is concerned with flow from the filter to the drain it was not necessary to reproduce the natural ground condition which would normally exist outside of the filter material.

The test apparatus, Fig. 3, is essentially a plywood tank 52 in wide, 40 in deep and 48 in long. A filter section, 24 in wide and 36 in deep, was located inside the tank. The filter section extended the full length of the test tank, and the top of both sections were at the same elevation. This arrangement causes the filter area to be surrounded by a U-shaped section which is utilized for the introduction of water to the filter material. The walls and floor of the filter section are composed of open-type subway grating overlaid on the filter side with 80-mesh brass cloth to prevent the loss of filter material to the water supply chamber.

The 8-in-diameter, perforated, corrugated metal drain pipe was located midway between the walls of the filter section so that the minimum thickness of filter material on the sides and bottom was 8 in.

An adjustable-height overflow weir is connected to the water supply chamber with two 2-in hoses to insure that the tests were conducted with conditions of constant head. A water stage recorder is used to provide a continuous record of depth of water outside the filter.

Flow intercepted from the filter by the drain pipe passes through the pipe and into a 7.5-deg V-notch weir tank for measurement. The weir tank is also equipped with a water stage recorder to provide a continuous discharge record and with a standard hook gage for checking purposes. After the water passes over the weir it is pumped to a drain.

A record of inflow water temperature is obtained through the use of a two-pen recording thermometer. One bulb of the thermometer is in the water supply chamber and the other is in the filter material adjacent to the pipe.

A basket of 80-mesh brass cloth is located at the entrance to the weir tank to catch filter material that is washed out of the pipe.

Arrangement of the equipment in the laboratory is shown in Fig. 4.

The initial phase of the experimental work was calibration of two samples of riveted, perforated corrugated metal pipe. Both pipes had a nominal diameter of 8 in, and nominal perforation diameter of $\frac{5}{16}$ in The first sample tested was standard galvanized pipe, and the second sample was bituminous-coated galvanized pipe. The calibration tests were performed without sand in the filter box.

The results of the calibration work are shown on Fig. 5 and are summarized in the following table.

Table 1—Calibration of Drain Pipes

Head—Ft	*Intercepted Flow—CFS per Ft*		*Ratio Galv/Bit*
	Galvanized	*Bituminous*	
0.2	0.016	0.00046	34.8
0.5	0.024	0.00089	27.0
1.0	0.043	0.00146	29.4
1.5	0.054	0.00170	31.8
2.0	0.064	0.00240	26.7

The last column of the table indicates that throughout the range of the test the galvanized pipe exhibited about 30 times the interception ability of the bituminous-coated pipe. Both pipes were tested as they were received from the supplier. Bituminous material completely closed many of the holes, and all of the lap joints, on the coated pipe. The very significant difference in interception ability was caused by the bituminous coating.

Examination of the uncoated pipe rating curve, Fig. 5, shows that the control equation is similar to the orifice equation. The slope of the curve is 0.57.

The second phase of the experimental program was determination of the filter rating curve with concrete sand in the filter box. Only the uncoated drain pipe was used in this study. The experimental rating curve is presented as Fig. 7. It is noted that the five experimental values fall on a smooth curve. Also shown on Fig. 7 is the theoretical rating curve for the filter. This curve is based upon Eq. 4, and an assumed value for the permeability of concrete sand equal to 0.00167 ft per sec (0.1 ft per min). The lower portion of two curves are virtually parallel, thus indicating laminar flow (i.e., exponent of y in Eq. 4 is 1.0). The marked increase in slope of the experimental curve (at head approximately equal to 1.0) indicates that flow in the filter is probably approaching turbulent conditions. To illustrate this transition the curve on the figure has been extrapolated to a slope of 2:1. The extrapolation has no design significance, but it does illustrate the anticipated transition from laminar to turbulent flow.

Corollary to the transition from laminar to turbulent flow on the experimental curve is the invalidation of the upper portion of the theoretical curve. This line is based upon Eq. 4, which applies only to the laminar state of flow.

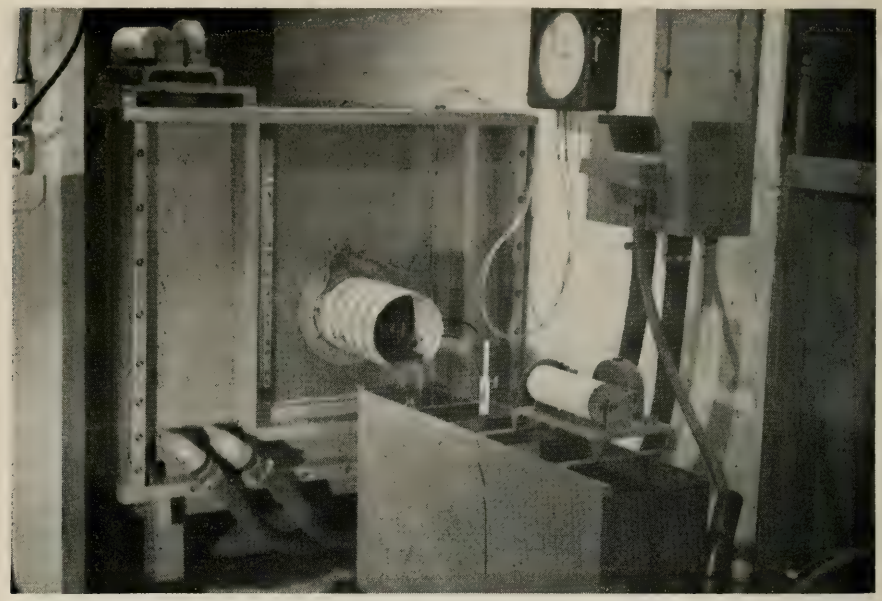


Fig. 4—Photograph of experimental apparatus. Filter of concrete sand is visible through the lucite end of test tank. Water stage recorders on test tank and overflow weir provide continuous record of water supply and discharge.

The initial phases of the experimental activity considered that the filter was static with respect to time. Present experimental activity is concerned with the change of flow through the filter relative to time. Three hydrographs of rate of flow versus time are presented as Fig. 8. Conclusions are not available regarding this portion of the study, but it is interesting to note that after 70–80 hr of operation the discharge—time relationship stabilizes somewhat. We are encountering small changes in flow rate, at regular intervals, after the 80-hr time. The cause of these slight, but regular, decreases in discharge has not been determined at the time of this writing. It has been determined that the decrease is not caused by variation in supply chamber head, water temperature or water quality.

Probably the most significant result of the experimental program is the finding that filter material washed into the drain pipe has the same particle size distribution as the material in the filter box. Mechanical sieve analysis of sand carried through the pipe, for all three operating heads, has indicated no real difference in grain-size distribution. This indicates that the material is not sorted at the pipe perforation as is usually assumed.

The importance of this finding lies in the fact that if sorting does not occur then "bridging" of larger particles does not occur. Since for any given head the loss of filter material virtually terminates after the first 70–80 hr of operation it is concluded that natural arching at the pipe hole is primarily responsible for filter stability. The natural arching is dependent upon lateral forces exerted upon the individual grains, which in turn is dependent upon initial compaction. Thus, based upon the conditions of the laboratory program, and considering a limited number of tests, it appears that initial compaction of the filter sand is the dominant factor influencing filter stability.

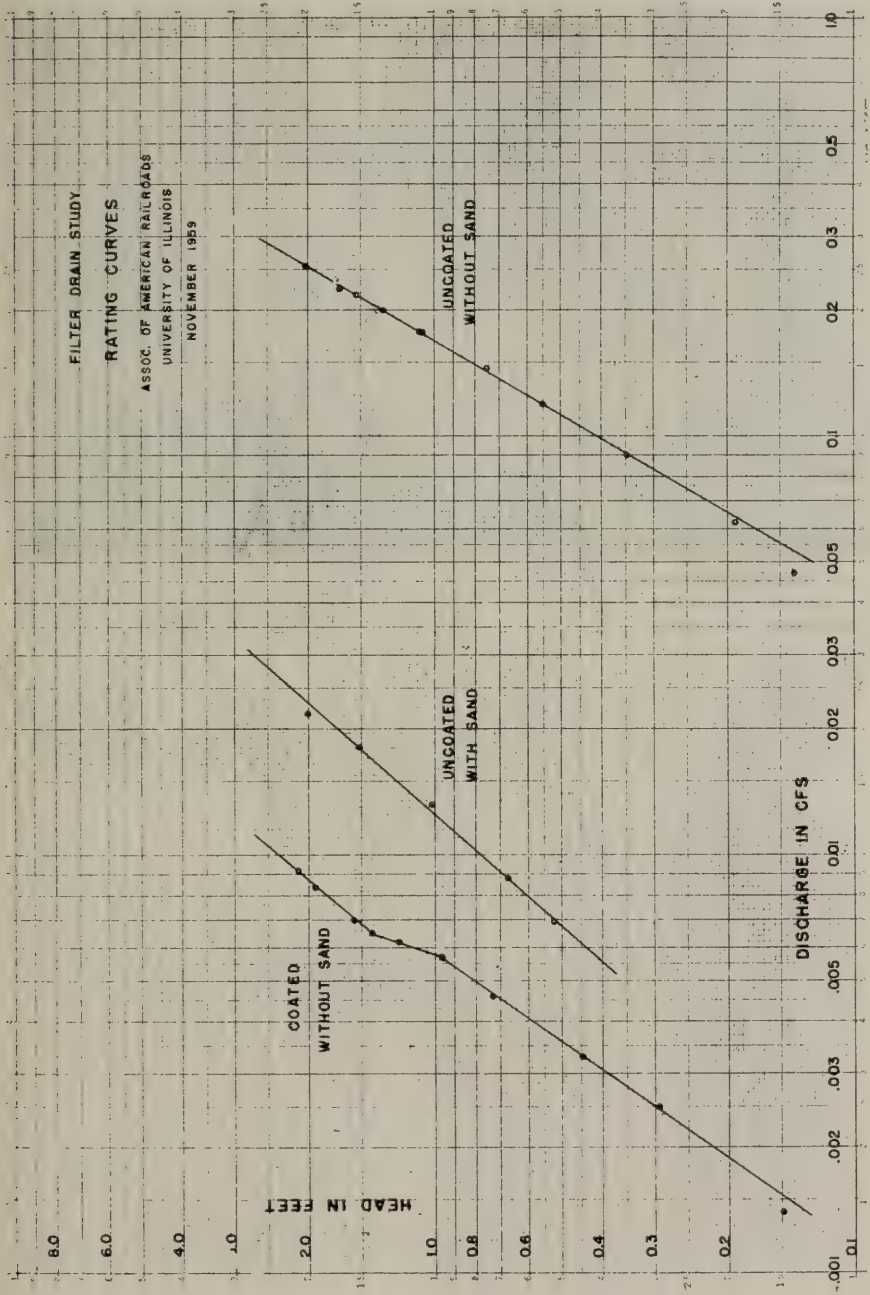

FILTER DRAIN STUDY
RATING CURVES
ASSOC. OF AMERICAN RAILROADS
UNIVERSITY OF ILLINOIS
NOVEMBER 1959
UNCOATED
WITHOUT SAND
UNCOATED
WITH SAND
COATED
WITHOUT SAND
HEAD IN FEET
DISCHARGE IN CFS
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.3
0.2
.001
.002
.003
.005
.01
.02
.03
.05
0.1
0.2
0.3
0.5
1.0

Fig. 5.

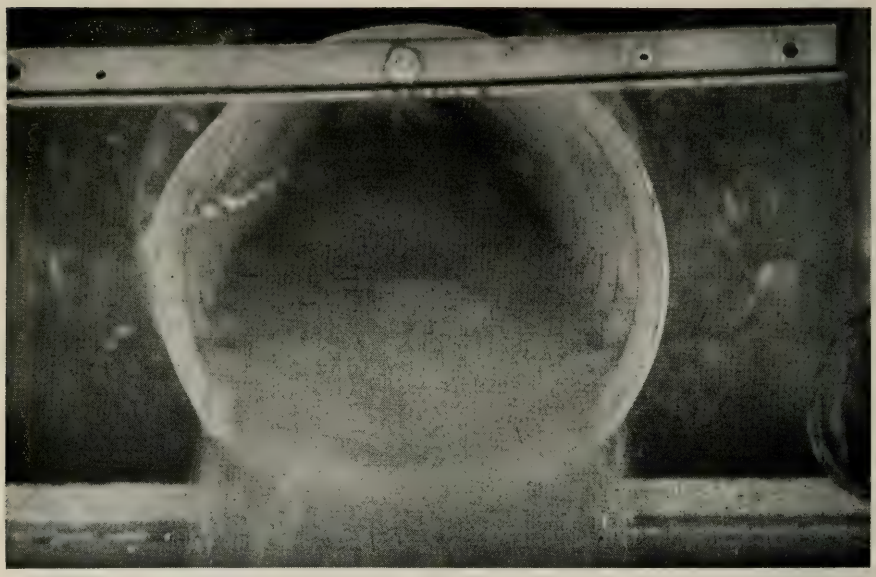


Fig. 6—Calibration of corrugated metal pipe. The rate of flow is 0.25 cfs under a head of 2 ft without sand in the filter box. This flow would result from approximately 150 ft of filter with the same pipe operating under a head of 0.5 ft.

This conclusion is further verified by examination of Fig. 9 which presents three grain-size curves for the initial operating head. The 95-percent size of the filter material is 2.2 mm and the nominal size of the pipe perforation is $\frac{5}{16}$ in, or 7.93 mm. Thus, the hole is 3.6 times larger than the 95-percent particle. This ratio is so large, and the number of perforations in the 4-ft test length is so great, that it is believed the possibility of random sorting at the holes is of little importance.

The curves of Fig. 9 also indicate sorting of lost filter material by final location. Virtually all particles 0.3 mm in diameter and smaller are carried out of the pipe and into the basket. The 60-percent size of material lodged in the drain pipe was about equal to that of the filter material, but from this point upward there is a marked difference in the two curves. This relationship is primarily fixed by the rate of flow and slope of the drain pipe. Similar curves have been prepared for the other tests and like characteristics noted.

Survey of Present Practice

One of the problems originally faced by the research program was the lack of information relative to present design criteria and operation of existing filter drains. To help overcome this deficiency a questionnaire was prepared and circulated to the chief engineers of AAR Member Roads and to members of Committee 1—Roadway and Ballast, AREA.

Response to the questionnaire was prompt and quite complete. A total of 78 questionnaires were returned, and many of them contained additional explanations and specific examples. The questionnaires have served a real function in the research program. The

(Text continued on page 690)

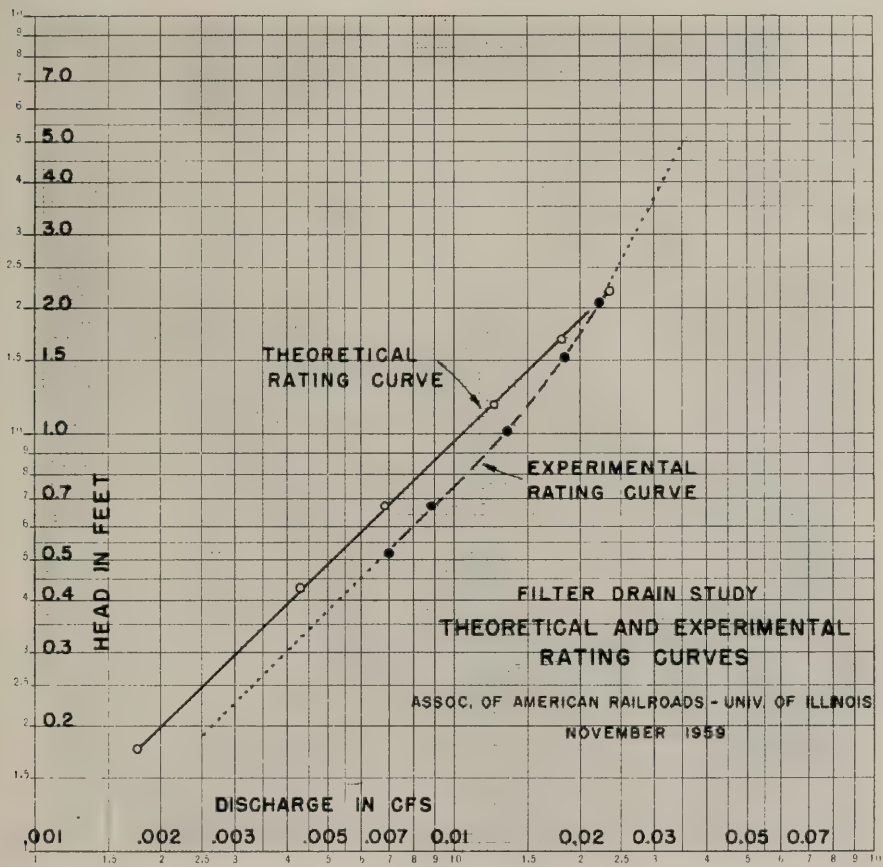

THEORETICAL
RATING CURVE
EXPERIMENTAL
RATING CURVE
FILTER DRAIN STUDY
THEORETICAL AND EXPERIMENTAL
RATING CURVES
ASSOC. OF AMERICAN RAILROADS - UNIV. OF ILLINOIS
NOVEMBER 1959
HEAD IN FEET
7.0
5.0
4.0
3.0
2.0
1.5
1.0
0.7
0.5
0.4
0.3
0.2
DISCHARGE IN CFS
.001
.002
.003
.005
.007
0.01
0.02
0.03
0.05
0.07

Fig. 7.

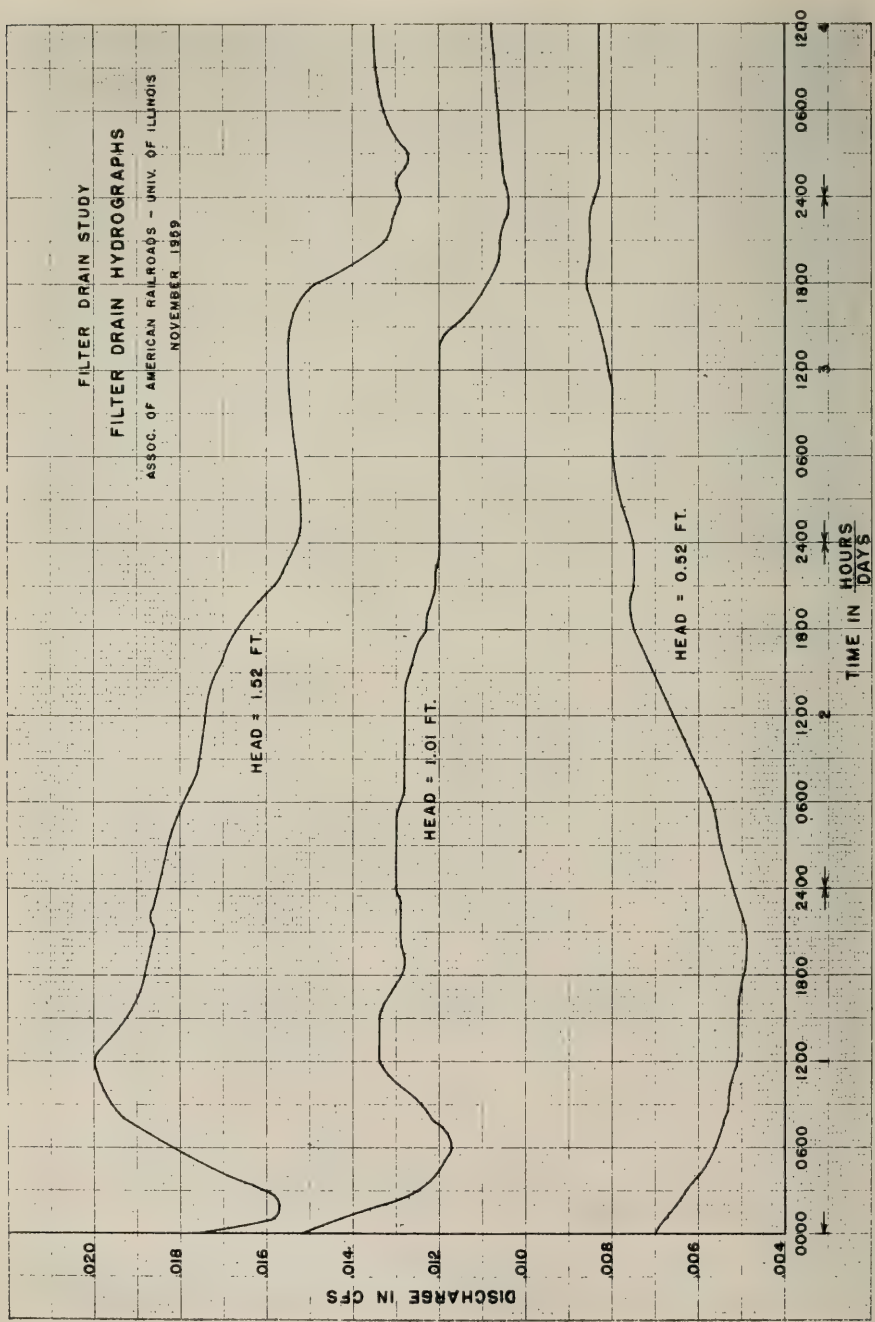

FILTER DRAIN STUDY
FILTER DRAIN HYDROGRAPHS
ASSOC. OF AMERICAN RAILROADS - UNIV. OF ILLINOIS
NOVEMBER 1959
HEAD = 1.52 FT.
HEAD = 1.01 FT.
HEAD = 0.52 FT.
DISCHARGE IN CFS
.020
.018
.016
.014
.012
.010
.008
.006
.004
0000
0600
1200
1800
2400
0600
1200
1800
2400
0600
1200
1800
2400
0600
1200
1
2
3
4
TIME IN HOURS
DAYS

Fig. 8.

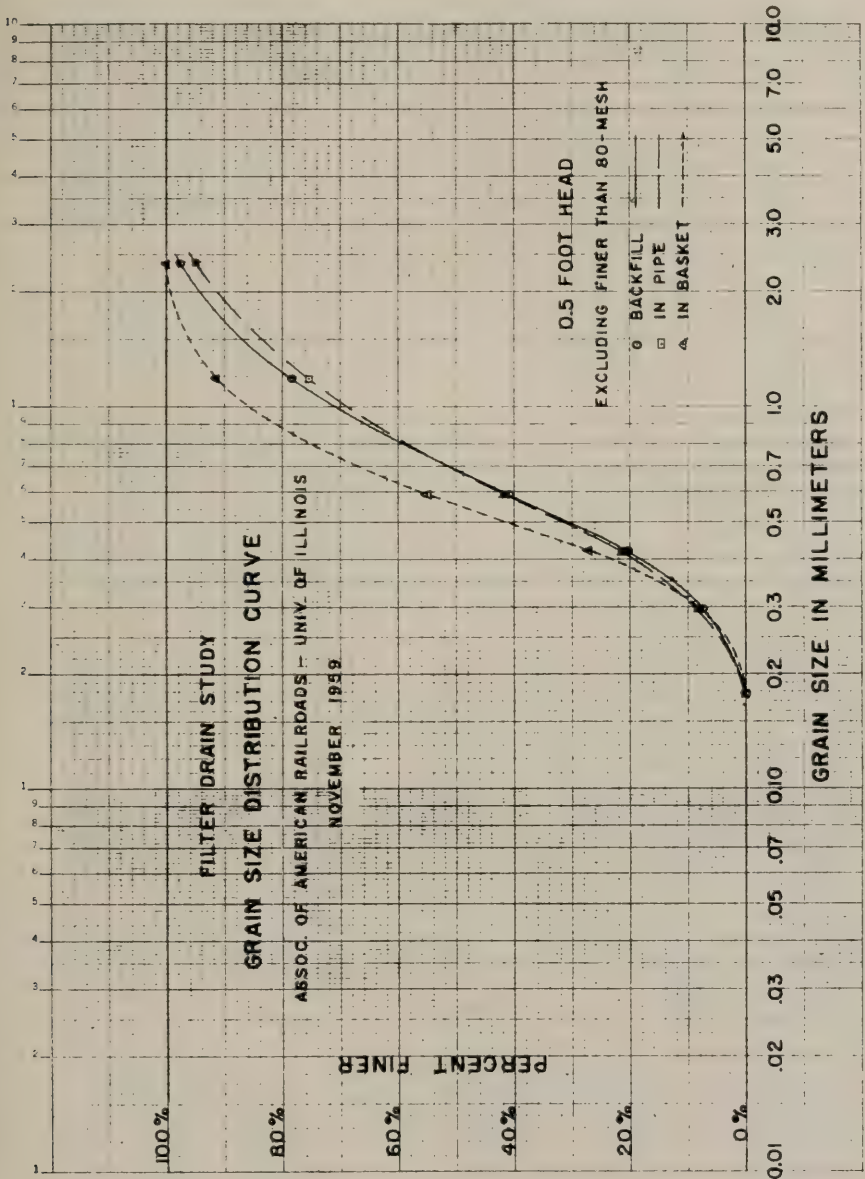

FILTER DRAIN STUDY
GRAIN SIZE DISTRIBUTION CURVE
ASSOC. OF AMERICAN RAILROADS – UNIV. OF ILLINOIS
NOVEMBER 1959
0.5 FOOT HEAD
EXCLUDING FINER THAN 80-MESH
BACKFILL
IN PIPE
IN BASKET
PERCENT FINER
100%
80%
60%
40%
20%
0%
GRAIN SIZE IN MILLIMETERS
0.01
.02
.03
.05
.07
0.10
0.2
0.3
0.5
0.7
1.0
2.0
3.0
5.0
7.0
10.0

Fig. 9.

cooperation of the individuals completing the questionnaire is very much appreciated. A tabulation of responses to the questionnaire forms a part of this report.

Study of the responses indicate that many of the railroads use more than one type of drain pipe, but of all installations about 70 percent include perforated corrugated metal. Over half of these installations have the perforations at the bottom of the pipe.

Clay drain tile is used in about 10 percent of the installations and perforated vitrified tile, concrete and specials are used in the remaining cases.

The most frequently used pipe size is 8 in. Apparently 4-in-diameter pipe has been virtually abandoned, and almost 20 percent of the installations include pipe larger than 10 in. The engineers indicated that in over 80 percent of the cases the size of pipe was determined for the particular location.

The use of filter material around the drain pipe is almost universal, except for particular local conditions, and the most frequently used material is crushed stone. It is of interest to note that 62 percent of the filter installations used crushed stone or washed gravel. Both materials have unusually large pore spaces which under present-day theory is considered undesirable. The questionnaires do not indicate that these filters are causing trouble.

The questionnaires indicate that in general the engineers are fairly well satisfied with existing installations, but that in about half the cases they do have minor trouble with silting of drain pipes and clogging of the filters.

Using average figures it appears that over 100,000 ft of filters are installed each year. Based upon a 1957 bid report this represents an annual investment of over $250,000 for new drains. The questionnaires indicate that most of the drains now being installed are in classification yards or in conjunction with new terminal facilities.

Acknowledgements

The study reported is being conducted cooperatively by the Association of American Railroads and the University of Illinois. The contract officer for the AAR is G. M. Magee, director of engineering research, and for the University, Professor Ross J. Martin, director of the Engineering Experiment Station.

Technical and operating supervision of the study is provided by Rockwell Smith, research engineer roadway, AAR, and by Professor J. C. Guillou, research associate professor of hydraulic engineering. Special acknowledgement is due Mr. Smith for his interest and cooperation in the operation of the program.

The research project is being conducted by the staff of the Hydraulic Engineering Laboratory of the University, under the direction of the writer. David Robb was in charge of the literature study and model design work, and Richard Lanyon carried out the experimental program.

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Summary of Responses to Questionnaire on Underdrain Practice

	Number	Percent
A. PRESENT CONSTRUCTION PRACTICE		
1. Type of Pipe		
a. perforated corrugated metal	77	71
b. perforated vitrified tile	3	3
c. perforated concrete	4	4
d. porous tile or concrete	8	7
e. clay drain tile	14	12
f. other	3	3
Total	109	100
2. Type of Joints		
a. open joints	24	23
b. tight joints	26	25
c. jute joints	0	0
d. papered joints	9	9
e. bands	43	41
f. other	2	2
Total	104	100
3. When perforated pipe is used holes are located		
a. up	7	8
b. down	53	62
c. depends on groundwater conditions	26	30
Total	86	100
4. Sizes of pipe used		
a. 4 in	13	7
b. 6 in	39	21
c. 8 in	62	34
d. 10 in	36	19
e. 12 in	34	18
f. larger than 12 in	1	1
Total	185	100
5. Pipe size is		
a. standard	13	17
b. determined for each installation	65	83
Total	78	100
6. Percent of installations that filter material is used around the pipe		
a. 0– 30	5	6
b. 30– 70	13	17
c. 70–100	60	77
Total	78	100
7. Use of filter material is determined by		
a. soil inspection at each installation	32	42
b. policy (it is always used)	45	58
Total	77	100
8. Type of filter material used		
a. crushed stone	53	38
b. washed gravel	33	24
c. bank run gravel	14	10
d. concrete sand	20	14
e. graded mixture	7	5
f. select granular (local borrow)	12	9
Total	139	100
9. Filter material is used because of		
a. previous failures without use of filter	19	15
b. recommendation by pipe manufacturer	19	15
c. recommendation by an engineering study	24	19
d. personal experience with performance	63	51
e. other	0	0
Total	125	100

SUMMARY OF RESPONSES TO QUESTIONNAIRE ON UNDERDRAIN PRACTICE (Continued)

	Number	*Percent*
10. Percent of installations in which drain pipes are designed to carry both subsurface and surface flows		
a. never	10	14
b. 0– 30	32	43
c. 30– 70	20	27
d. 70–100	12	16
Total	74	100
B. BEHAVIOR OF INSTALLED DRAINS		
1. Trouble with silting of drain pipes		
a. sometimes	41	55
b. very seldom	34	45
Total	75	100
2. Trouble with internal clogging of filter material		
a. yes	36	49
b. no	37	51
Total	73	100
3. Trouble with clogging of filter at interface with native soil or unselected backfill		
a. yes	35	50
b. no	35	50
Total	70	100
4. Have you abandoned use of certain types of pipe because of poor performance?		
a. yes	30	39
b. no	48	61
Total	78	100
5. Have you abandoned use of certain types of filter material because of poor performance?		
a. yes	20	27
b. no	53	73
Total	73	100
6. The nature of the clogging problem is principally		
a. mechanical	49	73
b. chemical	3	5
c. unknown	15	22
Total	67	100
C. GENERAL COMMENTS		
1. About how many lineal feet of underdrain do you install per year?		
a. 0– 500	37	49
b. 500–1500	17	23
c. 1500–5000	15	20
d. over 5000	6	8
Total	75	100
2. Are you generally satisfied with your present design and construction procedures?		
a. yes	67	87
b. no	10	13
Total	77	100
3. Do you have any field installations that are causing particular trouble?		
a. yes	12	16
b. no	64	84
Total	76	100
4. Do you think it would be desirable for the research group to undertake a detailed study of troublesome situations?		
a. yes	29	42
b. no	40	58
Total	69	100

Report on Assignment 7

Tunnels

(a) Ventilation; Changes Necessary for Operation of Diesel Power
(b) Clearances; Methods Used to Increase, Collaborating with Committee 28.

J. B. Farris (chairman, subcommittee), M. W. Cox, A. P. Crosley, W. G. Dyer, L. G. Reichert, J. M. Thomson.

Your committee submits as information the following report on Assignment 7 (a). No report is presented this year on Assignment 7 (b).

FOREWORD

In connection with Assignment 7 (a) on tunnel ventilation, G. V. Guerin, chief engineer of the Great Northern Railway, presented an address to the 1958 Convention dealing with ventilation problems in the Cascade Tunnel (Proceedings, Vol. 59, 1958, page 1288).

Included herein is a report covering the necessity, selection and operation of the Cascade Tunnel ventilation system prepared by the Great Northern Railway, and a report dealing with the analyses and tests used by the consulting engineer in developing the system which was installed.

INTRODUCTION

Ventilation changes in a tunnel to permit operation of diesel locomotives becomes necessary when fixed physical conditions of the tunnel are such that insufficient air is available for cooling the locomotives, or when exhaust gases accumulate in objectionable quantities under desired operating conditions.

The fixed physical conditions at the tunnel which directly influence ventilation are profile, tunnel length, tunnel cross section, roughness of the tunnel walls, elevation of portals and prevailing winds. Variable operating conditions affecting ventilation are lengths of trains, desired operating speeds, and number, size and type of locomotive units used. The physical and operating conditions of each tunnel are interrelated in such a manner as to make necessary a careful analysis of each location.

When a train enters a tunnel, it tends to push the air in the tunnel ahead of the train. The degree of this phenomenon is governed by the relation between the cross sectional area of the tunnel and the cross sectional area of the train, the length of the tunnel, the roughness of the tunnel walls, the length of the train and its speed. The air between the tunnel walls and the train tends to move with the train, carrying exhaust gases and heat from the locomotives with the train. As the rear of the train passes through the tunnel, fresh air is drawn in behind.

In long tunnels on steep grades heat from the leading diesel units tends to cause trailing units to overheat, requiring some arrangement for additional cooling. Since exhaust-gas accumulation is also a problem in long tunnels, forced-air ventilation offers a solution to both problems.

Tunnels that are little longer than the length of the average train operated through it usually require no additional ventilation because the locomotive units do not have

time to heat up excessively, and the rear of the train can pull fresh air into the tunnel to replace exhaust gases.

If one end of the tunnel is blocked, the train will build up a relatively high pressure ahead of it as it approaches the blocked end. A volume of air equal to the volume displaced by the train will be forced back along the area between the train and the tunnel surface. The pressure so generated is referred to as the piston effect pressure, which may be either positive or negative, depending upon the direction of movement of the train toward or away from the blocked portal. It is conceivable that instances may occur where the use of a door alone to take advantage of the piston effect would furnish sufficient air for cooling diesel locomotives on heavy grades.

The need for careful tests and analysis for the selection of a tunnel ventilating system cannot be over emphasized.

Part 1—The Great Northern Railway Cascade Tunnel Ventilation System

The west portal of the Cascade Tunnel of the Great Northern Railway is located 97 rail miles east of Seattle, Wash., and in its length of 7.79 miles pierces the main ridge of the Cascade Mountains. The longest railway tunnel in the Western Hemisphere, it is a straight, single-track, concrete-lined bore on a uniform grade of 1.57 percent ascending from west to east. The summit of the Cascade crossing is at the east portal of the tunnel, which is 634 ft higher than the west portal.

The tunnel is in the former electrified section of the main line which extended from Wenatchee on the east to Skykomish on the west, a distance of 73 route miles. This section of the railroad includes heavy mountain grades up to 2.2 percent which prevail on both sides of the tunnel. Prior to ventilation of the tunnel, electric locomotives had been used almost exclusively to operate trains through the tunnel since it was opened in January 1929. Exceptions were during World War II when all available forms of motive power were used in conjunction with the electric locomotives and in more recent years when certain passenger trains have been diesel powered through this section and the tunnel.

Completion of dieselization of the railroad on both sides of the electrified section reversed the former favorable position electric operation had enjoyed with respect to the earlier steam operation. That is, it became evident that the resulting part-diesel, part-electric operation over the division involved was more expensive than all-diesel operations would be, provided a feasible method could be devised for operating all-diesel-powered trains through the Cascade Tunnel.

In 1954 the railway company made an economic study to determine the extent of annual saving to be obtained by changing to all-diesel operation through the electrified section, including the tunnel. This study, completed in September 1954, indicated an estimated annual saving in the order of $996,800, or an annual return of 76 percent on a net investment of $1,314,000. In spite of the fact that this study did not include the investment cost of a ventilation system for the tunnel or its tunnel operating cost because that information was not available, the results in favor of all-diesel operation were even more promising than originally anticipated and certainly justified the decision to employ an engineering firm to determine the feasibility of operating diesels through the tunnel and to check the economics of the proposed change.

A consulting engineer was employed in December 1954 to determine the feasibility of operating trains through the Cascade Tunnel with diesel-electric locomotives and to

make an economic analysis of the proposed change from electric to all-diesel operation between Wenatchee and Skykomish. The economic report submitted in April 1955 confirmed the results of the railway company's earlier economic study mentioned above. This latter report included estimated investment and annual operating costs for a ventilation system for the Cascade Tunnel. Because of this and certain differences in anticipated retirements and details of proposed operation as compared to the earlier railway company study, the report estimated an annual saving of $792,400, or a return of 53 percent, on a gross investment of $1,476,500. Nevertheless, this report still indicated very substantial savings in favor of all-diesel operation and economies that greatly exceeded any to be obtained by extending the electrification.

The principal action necessary to secure these economies, then, was the ventilation of the Cascade Tunnel. The railway company knew from actual experience in operating diesel locomotives through the tunnel that two major problems limited the effective use of such power in the tunnel. First, the overheating of trailing units of multiple-unit locomotives while hauling heavy freight trains eastbound or upgrade in the tunnel, and second, the smoke and noxious gases that are produced by the diesel engines in the limited confines of the tunnel and the discomfort and possible hazard they present to the train and engine crews and workmen in the tunnel.

To clarify the first problem it may be explained that when a diesel locomotive operates in a tunnel, the hot exhaust gases and the heat from the cooling radiators cannot escape from the immediate vicinity of the train. In the case of multiple-unit locomotives required in the mountain-grade territory of the Cascade Tunnel, the first or leading unit has a continuous supply of cool air but each successive trailing unit operated in an atmosphere of successively higher temperature because of the heat discharged from the preceding unit. When the air available to the last unit becomes too hot to provide adequate radiator cooling, it "trips out" or drops its load. This places the entire load on the remaining units which must work harder to maintain speed; this increases their heat discharge rate and thereby the possibility of the next-to-last unit overheating and finally a complete stall of the train.

Westward freight trains present no overheating problem in the tunnel because the engines are idling, and the train is being braked down grade. Also, overheating is not a problem for locomotives of light freight trains and passenger trains in either direction because of their higher speed and lighter load conditions.

The railway company conducted tests at the Cascade Tunnel during the summer of 1954 and determined the amount of excessive overheating of diesel freight locomotives operating under load up grade in the tunnel. These tests also indicated that auxiliary cooling of the diesel engines consisting of water sprays on the exterior of the engine cooling water radiators and/or additional air intakes in the floor of the locomotive cabs tended to alleviate the overheating. Subsequent field tests made in February and March 1955 proved that this type of modification would prevent excessive overheating on a four-unit, 6000-hp locomotive trailing approximately 2500 tons up the tunnel grade or for two 6000-hp locomotives hauling approximately 5000 tons.

The consulting engineer considered this and a variety of other schemes in his investigation to determine a suitable method for operating diesels through the tunnel. After due consideration mechanical ventilation was selected as the most desirable method. This consists of supplying air to the tunnel by mechanical means to prevent excessive engine heating and to clear the tunnel of smoke and gases.

In proceeding with the development of this method the consulting engineer studied diesel locomotive operations through other railroad tunnels, particularly the Moffat Tunnel in Colorado of the Denver & Rio Grande Western Railroad, as well as vehicular

tunnel ventilation systems. However, there was no existing installation or experience that approached the problem at hand. The limitations and conditions imposed by the length and size of the Cascade Tunnel and the maximum heating of the diesels working up the adverse grade with a ventilation system in operation were not covered by previous experience.

The consulting engineer conducted extensive field tests at the tunnel to determine the requirements to be fulfilled by a mechanical ventilation system and to obtain data to permit selection of the equipment for such a system. Several schemes were considered for ventilation of the tunnel, and two were judged to meet most nearly the requirements of preventing excessive engine overheating and clearing the tunnel at a reasonable cost. The first scheme involved blowing air against ascending trains and through the empty tunnel after train passage to clear it; the fan installation would be at the east portal. The second method would blow air past ascending trains in the direction of travel and through the empty tunnel for clearing with the fan installation at the west portal. It was determined that the second method would require about 1,000,000 cfm of air and approximately 3000 hp to provide effective cooling of the engines as compared to about 200,000 cfm and a much smaller horsepower requirement to obtain the equivalent cooling blowing against ascending trains. An advantage of blowing air with an ascending train would be that the tunnel would be clear of smoke as soon as the train passed the east portal, and the air would be helping the train along instead of opposing it. However, the first scheme of blowing air against ascending trains was selected as most advantageous and economical.

The final report of the consulting engineer covering the feasibility and outlining the technical considerations of operating diesel-powered trains through the tunnel was submitted in June 1955. It recommended ventilation equipment consisting in general of the following—all to be located at the east portal.

1. Two axial-flow, propeller-type, two-stage, reversible fans complete with close-off doors, direct drive a-c motors and starting equipment.
2. Portal door complete with operating equipment, seals, fail-safe mechanism and electric controls.
3. Standby diesel-electric a-c generating unit complete with auxiliary equipment for automatic operation.
4. Semi-automatic control system for fans and door.

Axial-flow, propeller-type fans were recommended because they have non-overloading characteristics, are reversible, have variable-pitch blades for varying their characteristics and most adequately meet the requirements of pressure and volume. Preliminary calculations showed that the ventilation requirements would be about 250,000 cfm of air against ascending freight trains and 550,000 cfm to clear the tunnel.

A portal door is necessary to close the east portal to prevent the escape of air when blowing against trains and to keep the adjacent fans from "short-circuiting" air-wise.

Standby electric power is essential because the successful operation of diesel-powered freight trains eastbound in the tunnel depends on a continuous supply of air. The proposed ventilation equipment was to be located in a relatively remote mountain area with no existing electric power distribution facilities. The only available source of electric power from a utility was a long 115-kv transmission line which was known to be subject to interruptions by winter storms and avalanches.

The plan of operation for this ventilation equipment as evolved by the consulting engineer in accordance with the railway company's requirements, contemplated that all

operations would be controlled remotely from a train-order station at Scenic, just west of the west portal, by attendant telegraph operators acting under the direction of a train dispatcher; or possibly from Berne, the first station east of the east portal. The operation of the portal door was to be semi-automatic in that it would be closed by the action of a telegrapher at the remote station but would open automatically on the approach of a train. This automatic opening was to be initiated by track circuits related to the automatic block signal system.

One fan would be used to blow against ascending or eastbound freight trains. The fan controls were to be interlocked to prevent their operation unless the portal door was closed, and the opening of the portal door would stop the fans.

Both fans would be operated in parallel or simultaneously to clear or flush the tunnel after passage of a train. It was expected that it would take about 25 min to flush the empty tunnel, and a time control was to be used to shut down the fans and open the portal door on completion of the flushing cycle. Although air would not be blown behind a descending or westbound train, the tunnel would be flushed after the train had cleared the west portal.

In the event of a failure of the regular power supply, the diesel-electric generator would automatically start, and one fan would be used for ventilating a train or flushing the tunnel. It was believed that one fan would clear the tunnel adequately, although it would take twice as long as both fans working together.

In addition to the control of the equipment as described above, it was recommended that certain information be made available to the operator at the remote control station. This would consist of the location of trains adjacent to and in the tunnel; position of the portal door—open or closed; fans on or off; generating unit on or off; fan pressure; and mechanical trouble.

The completed ventilation system consists of two 2-stage, propeller-type fans complete with steel discharge stacks and close-off doors. These close-off doors are located at the end of the discharge stacks and at the point of connection to the concrete ducts leading to the main tunnel. They are of the multi-louver, damper type with motor-driven operators. Control is arranged so that the close-off doors open when a fan motor starts and close when the motor is stopped.

The two fans are driven by 800-hp wound-rotor motors.

The fan motors are contained in the machinery building and connected directly to the fans shafts with 15-ft floating shafts. The machinery building is a 32- by 65-ft reinforced concrete structure 20 ft high. It is heated electrically with thermostat control. It also houses the standby diesel-electric generating set, which has a nominal rating of 750 kw at 0.8 power factor.

To eliminate heat from the diesel engine and the fan motors the machinery building is provided with its own ventilation system, which is thermostatically controlled. In addition, the building is equipped with plumbing, sewer and water supply.

The switchgear and motor-starting equipment is located in the machinery building. It is a totally enclosed free-standing assemblage of steel cubicals with the following overall dimensions: 19 ft 4 in long, 9 ft 8 in high, 5 ft 0 in deep. These cubicals contain a circuit breaker for the main power supply received from the electric utility, a second circuit breaker for the auxiliary or emergency power supply provided by the diesel-electric generator set, two fully magnetic reversible wound-rotor motor controls or starters for the two 800-hp ventilation fan motors, a generator auxiliary control cubical which contains the controls related to the diesel-electric generator set and an auxiliary power cubical which contains a transformer and panelboard to serve the auxiliary equipment related to the entire installation.

The secondary motor controls for the two fan motors are contained, one each, in two cubicals assembled together and located separately within the machinery building from the main switchgear assemblage. These two cubicals placed together have the following dimensions: 8 ft 0 in long by 9 ft 0 in high by 3 ft ½ in deep.

The switchgear is rated 2400 v, 3-phase, 60 cycles. Each of the above two circuit breakers has an interrupting rating of 50,000 kva. The main switchgear assemblage has a double bus arrangement, each bus rated 1200 amp. The two fan motor controls are arranged so that each can be connected to either bus. One bus is regularly used to supply power for all equipment from the main power service. The second one is connected to the diesel-electric generator set through its circuit breaker. This provides an arrangement whereby one fan motor and all auxiliary power-consuming equipment can be connected to the main power bus, and the second fan motor can be operated from the second bus connected to the generator set and independent of the main power supply.

The purpose of this double-bus arrangement is to permit the regular operation, if desired, of one fan motor from the standby generating unit. This would reduce the total maximum demand for power and result in a corresponding decrease in power cost. The load factor of the installation is such that the major portion of power cost is in the demand charge. Experience will indicate whether it will be more economical to operate one fan regularly with the diesel generating unit and the other from the regular utility power supply.

A new portal structure of reinforced concrete was built immediately adjacent to the existing east portal. This structure houses the portal vertical lift door and its operating machinery and protects it from the weather. It covers a portal opening 17 ft wide by 20 ft 10 in high. It is of all-steel construction, of the counterbalanced type, and power operated. It is designed to withstand a pressure of 100 lb per sq ft. It is equipped with seals that seal under positive or negative pressure.

The operation of the door is accomplished with a 7½-hp motor with a fluid drive connected to a self-locking worm gearbox. The gearbox is connected to a magnetic clutch which has zero slip at full load. The clutch, in turn, is connected to an arrangement of sprockets and roller chains for raising and lowering the door. In the event of a power failure the magnetic clutch is released and the counterweights open the door. A fluid coupling working against a magnetic brake controls the door speed when it is being opened by the counterweights. The fluid coupling runs idle during normal operation. The speed of opening under normal conditions is about 25 sec. Automatic opening in the event of a power failure takes about 20 sec. A hand chain with reduction gears is provided to open or close the door if no electric power is available. Finally, an emergency winch is provided as a third means of opening the door in the event all other methods are inoperative.

The portal structure also contains an airlock-type entrance to the tunnel for use when the portal door is closed and the tunnel is under pressure from fan operation. Railway signal equipment related to the operation of the ventilation system is also located in this structure.

Finally, there is a diesel fuel oil storage and supply system for the standby diesel-electric generating unit. This consists of two 10,000-gal underground tanks with facilities for filling from highway tank trucks or railroad tank cars. A small transfer pump is provided to fill automatically the day tank at the diesel engine from the storage tanks.

The complete ventilation system cost $750,000.

The entire ventilation system installation at the east portal was designed and built on the premise that it would be unattended. Consequently, in designing the remote control system it was essential that control and supervision of all equipment directly related

to the operation of the ventilation system be made available to the operator at the remote station. The train-order office at the station of Scenic just west of the west portal of the tunnel was selected as the location for the remote-control station. A spare pair of wires in an existing telephone cable through the tunnel is used for the remote control circuit.

The following is a partial list of the operations that may be controlled and the indications that are provided at the control console at Scenic:

1. Close, open and indicate position of portal door.
2. Start, stop and indicate No. 1 fan running.
3. Start, stop and indicate No. 2 fan running.
4. Forward and reverse control of fans.
5. Indicate No. 1 fan blowing or exhausting.
6. Indicate No. 2 fan blowing or exhausting.
7. Open, close and indicate position of main circuit breaker, for normal power supply.
8. Start, stop and indicate position of master control relay, for diesel generator unit.
9. Indicate power off or on at main bus.
10. Open, close and indicate position of diesel generator circuit breaker.
11. Open, close and indicate position of bus tie contactor.
12. Indicate hot bearings, No. 1 fan.
13. Indicate hot bearings, No. 2 fan.
14. Indicate troubles for diesel unit, such as hot engine, low oil pressure, etc.

In addition to the above and the usual supervision of remote circuit and local-supervisory control, indication check, etc., the supervisory control console includes two automatic sequence controls which are used almost exclusively to operate the ventilation system. One is a "Full Ventilation" sequence and the other a "Flushing Ventilation" sequence. Initiation of either one of these controls by the operator at Scenic sets up an automatic sequence of operations of the ventilation system that requires no further action on the part of the operator other than observation of the control console indications to insure that everything is functioning properly.

A description of these sequences will explain the operation of the ventilation system. Initiation of the "Full Ventilation" control is made on the approach of an eastward train at Scenic. First, the portal door closes and then one fan starts. This condition remains as the train passes through the tunnel. When the train, as it approaches the east portal, moves on to a track section about 3250 ft from the portal door, a condition is established in the railway signal circuits that is repeated to the electric controls for the portal door and causes it to open. Simultaneously, the fan stops. In the event there is a failure in this operation and the door does not open, the signal, just west of the portal will not clear and the train, which has been slowed to restricted speed, will stop.

While the train passes through the portal, the door cannot be closed because its controls are interlocked with the signal system. When the last car of the eastward train clears the east end of a track section at a point 65 ft east of the east portal, another circuit condition is established through the signal system to close the portal door again, and both fans are started in sequence—not simultaneously. The opening of the portal door and stopping the fan on the approach of the eastward train and the closing of the door and starting of the fans after passage of the train is performed independently of the supervisory control system. However, this last operation of closing the door and starting

both fans, which is the beginning of the flushing part of the sequence, starts a timer in the supervisory control system. At the expiration of the time period for which the timer is set, the supervisory control stops both fans and opens the portal door and otherwise returns the ventilation equipment and control system to its normal "off" position and ready for the next operation.

The "Flushing Ventilation" control is used after the passage of westward trains. When a westward train passes Scenic the operator initiates this control. The portal door closes, both fans start in sequence and the timer in the supervisory control is started. When the time period has elapsed, the system is shut down as in the full ventilation sequence.

Either of these automatic sequences may be interrupted at any time if necessary and, of course, the individual controls may be used to operate each piece of equipment separately if desired. In the event of a power failure during ventilation, the door opens and the fan or fans stop. If the length of interruption exceeds the time period set in the time delay for starting the standby diesel-electric generating unit, it starts and it is then necessary for the operator at Scenic to re-initiate the ventilation sequence that was interrupted.

Local controls are provided in the machinery building at the east portal to permit control and operation of all ventilation equipment from that point if necessary.

The results obtained with the ventilation system as related to the operation of diesel-powered trains through the Cascade Tunnel have been most satisfactory and gratifying. The ventilation system in itself has not placed any significant limitation on train operations. Diesel locomotives are regularly hauling as high as 5500-ton freight trains eastward through the tunnel as compared with a limit of 5250 tons for the electric locomotives. In fact, tests and experience indicate that the diesels can handle more than 5500 tons eastward through the tunnel without excessive engine heating. Elimination of the short electrified section has reduced the average running time of freight trains over the district by at least 1 hr. Experience to date indicates that the actual saving in operating expense resulting directly or indirectly from this change is exceeding the most optimistic estimates.

Part 2—Field Test and Analysis of Cascade Tunnel for Design of Ventilating System

Description of Cascade Tunnel

Cascade Tunnel, located 49 miles west of Wenatchee on the Cascade Division of the Great Northern Railway, is a concrete-lined, single-track, straight bore which ascends a uniform grade of 1.57 percent from west to east, except for a short section of vertical curve at the east portal. The tunnel is 7.79 miles long and has a cross-sectional area of 314 sq ft.

About 70 ft south and parallel to Cascade Tunnel is Pioneer Tunnel, which is partly concreted and sparsely timbered, and connected to Cascade Tunnel by a number of crosscuts. Its cross section is not uniform, but averages about 100 sq ft.

Originally, it extended about 28,000 ft from a portal at the west end, terminating in a crosscut to Cascade Tunnel. The east end has since caved and has been abandoned. The most easterly crosscut now open to the main tunnel is No. 12 A about 17,000 ft east of the west portal. Pioneer Tunnel is used presently for drainage of the main tunnel.

Field Tests

The characteristics of Cascade Tunnel as an airway are dependent on various constants. Approximate values for some of these were determined from field tests; others are based on tunnel dimensions, typical trains, or fluid theory.

The field measurements were made by the consulting engineer in conjunction with the Great Northern Railway during February and March 1955. The purpose of the tests was to evaluate:

1. Resistance of Cascade and Pioneer Tunnels to the flow of air.
2. Percentage of total air flow diverted through Pioneer Tunnel.
3. Natural draft in both tunnels.
4. Percentage of air carried ahead of trains with tunnel open.
5. Piston effect of trains in tunnel with the east portal blocked by a temporary door.
6. Effect of closed doors at the east portal on overheating of engines.

The test results were influenced by the following factors:

1. Because it was necessary to provide clearance around the trolley wire, the temporary door used in the piston-effect tests was not air tight.
2. The effect of air short-circuiting through crosscuts to Pioneer Tunnel could not be evaluated.
3. Trains were not in every case typical.
4. Measurements were necessarily made at low air flows.

However, the values obtained are consistent with known values for other tunnels and are adequate for the intended purpose.

Natural Draft

The measurement of natural draft indicated that a pressure differential of ± 1 in of water might occur between the portals of the main tunnel. This would increase or decrease the total pressure against which the fan must operate, and has the effect of shifting the zero-pressure axis to one or the other of the dashed lines shown on Fig. 10.

Characteristic, With Tunnel Empty

Two values of the resistance factor for the tunnel, which shows how head loss varies with air velocity, were determined. One, the experimental value, was calculated from the results of field measurements of pressures and air velocities; the other, the theoretical value, was determined from fluid theory.

1. *Experimental Resistance Factor*

For a given airway at a given air density,

$$H_F = R' V^2 \qquad (1)$$

where H_F is the head loss, inches of water, R' is the resistance factor at the given air density, and V is the velocity, fpm.

Using Equation (1) and field measurements of densities and velocities due to natural draft, an average value of $R' = 3.4 \times 10^{-6}$ at $d = 0.072$ lb per cu ft was established.

2. *Theoretical Resistance Factor*

The basic law for the turbulent flow of fluids in straight ducts may be stated

$$h_F = \frac{f\ L'\ V^2}{2\ g\ D} \qquad (2)$$

in which h_F = head loss, feet of fluid
f = friction factor
L' = length of airway, feet
$g = 32.2$ ft/sec^2
D = diameter of equivalent circular duct, feet

Finding f for straight, smooth concrete-lined ducts to be 0.013 from Pigott's Diagram, Equation (2) may be solved to give h_F. Substituting h_F for H_F in Equation (1) and converting units, a theoretical value of $R = 1.7 \times 10^{-6}$ at standard air density may be found. Converting to air density = 0.072 lb per cu ft, gives $R' = 1.76 \times 10^{-6}$.

Because of the influence of the crosscuts to Pioneer Tunnel and the low air flows during the tests, the experimental value $R' = 3.4 \times 10^{-6}$ would be expected to be high. The tunnel is not a smooth concrete-lined duct, as it contains track, ties, and refuge bays; so the theoretical value of $R' = 1.76 \times 10^{-6}$ would be expected to be low. Therefore, the true value of resistance factor should be somewhere between the experimental and theoretical value.

Characteristic curves are shown on Fig. 1 for various conditions, using each resistance factor. Comparison of fan discharge values for the two resistance factors shows the difference in Q at any pressure, for either the train-in-tunnel curves (1–5) or the empty-tunnel curve (6), to be small enough to be unimportant. Therefore, further tests to determine a more precise value of R were unnecessary.

Characteristic, With Trains in Tunnel

R' relates pressure and velocity for the empty tunnel only; the effect on the tunnel characteristic of a train moving through the tunnel must also be considered.

A train moving in a tunnel pushes air in front of it. If one end of the tunnel is blocked, the train will cause relatively high (or low—depending on direction of train motion) pressure—the so-called "piston effect." The piston-effect pressure, similarly to the head loss, is related to the air velocity by a constant, except that in this case the velocity must be taken relative to the train. This may be stated

$$P = K\,(AS + Q)^2 \qquad (3)$$

where P = piston effect pressure, inches of water
K = a constant
A = cross-sectional area of tunnel, 314 sq ft
S = train speed, feet per minute
Q = fan discharge, cubic feet per minute

K is a constant for a given train, tunnel, and air density, and may be expressed

$$K = \frac{d\ N\ L}{(A - a)^2} \qquad (4)$$

in which d = air density = 0.072 lb per cu ft
N = Piston-effect constant
L = length of train, feet
A = area of tunnel, 314 sq ft
a = cross-sectional area of train, taken as constant, 160 sq ft

Since A, a, and d may be considered constant, Equation (4) may be written

$$P = N'\ L\ (AS + Q)^2 \qquad (5)$$

where $N' = \frac{d}{(A - a)^2}$. Equation (5) then applies to any train in Cascade Tunnel, when the air density is 0.072 lb per cu ft.

To determine N' a temporary wooden door was erected at the east portal, and pressures were measured during the approach of various trains. Q being zero and other quantities known, an average value of N' was found to be 7×10^{-15}.

Curves showing the relationship between piston-effect pressure and fan discharge for various hypothetical trains have been calculated and are plotted for fan blowing against train on Fig. 8 and for fan blowing behind train on Fig. 9. The tunnel characteristic for the condition of train in tunnel is obtained by adding the piston effect curves to the "tunnel empty" curves; these are shown on Fig. 1 and 2.

Use of Pioneer Tunnel

The possibility of using Pioneer Tunnel as an additional airway for smoke removal was investigated. Because of the high resistance factor for Pioneer Tunnel and the additional quantity of air to be moved, it was found that either with or without a second fan installation at the Pioneer Portal, more horsepower would be required to clear the main tunnel in the same time as would be required using the main tunnel alone.

Train Speeds

The speed of a train ascending the tunnel depends on two factors: the horsepower output of the engine, and the total resistance to the train's passage. Horsepower output is fixed by throttle position, and does not change while the throttle remains in the same position. With constant horsepower output, the train speed varies directly with the total resistance. Three components contribute to resistance:

1. The grade.
2. The inherent resistance of the train.
3. Air flow past the train.

Grade resistance is, and inherent resistance may be considered to be, independent of train speed. However, air flow past the train is caused by both train motion and fan discharge, and is quite sensitive to train speed. Hence, the train speed depends on the total resistance, which, in turn, depends on the train speed.

The interaction of these factors is mathematically complicated; a semigraphical solution is used. Shown on Fig. 3 are curves for 50-car, 2500-ton trains, and on Fig. 4 curves for 100-car, 5000-ton trains. Plotted on the upper part of the sheet are train-in-tunnel characteristics for 1-mph increments, and across these are drawn characteristics for three typical fans. On the lower part of the sheet are plotted the train speed—fan discharge relationships for the 6th, 7th and 8th throttle positions of the given train.

To find the fan discharge and train speed for a given fan and throttle position, find the fan discharge which gives the same train speed at intersection with the fan curve above and throttle position curve below.

Note that selection of a fan fixes the speed of a given train in a given throttle position. For a 50-car, 2500-ton train with throttle in position 8, operating up grades against fan "A", the speed will be about 16 mph. For a 100-car, 5000-ton train under the same conditions, the speed will be about 16½ mph. In either case, reduction of tonnage for the same number of cars will increase speed; but this will increase total pressure, as shown on the upper curves of Figs. 3 and 4.

These curves apply only for the case of fan blowing against ascending trains; a fan blowing behind a train will, of course, decrease total resistance and increase speed.

Cooling

When a diesel-electric locomotive operates in a tunnel, the hot exhaust gases cannot escape from the immediate vicinity of the train. The lead unit has a continuous supply of cool air, but the following units enter air that has been heated by exhaust gases. Theoretically, each unit raises the temperature of the air available to the one behind it. When the air temperature becomes too high to afford adequate radiator cooling, the unit overheats.

Without extensive field or model tests, only theoretical answers may be given for the overheating problem. Three hypotheses were considered, none of which admits a rigorous theoretical solution:

1. Cooling may be achieved by a high air velocity relative to the train, say 35 or 40 mph, which would bend the exhaust gases back in a flat airstream, preventing their entry into the intakes of succeeding units.
2. Cooling may be achieved by diluting the hot exhaust gases with a large quantity of cool air, thereby lowering the temperature of the air available at the intakes of the following units.
3. Some combination of 1 and 2 above.

Regardless of which of these theories is closest to the actual case, it is reasonable to assume that the greater the flow past the train, the less will be the overheating at successive units.

Although the first hypothesis probably would be the easiest to validate or reject by test, it cannot be proved or disproved without tests. The second hypothesis is believed to be qualitatively correct, but certain simplifying assumptions were made before a quantitative answer could be obtained. These assumptions are:

1. 50 percent of the total flow past the train is available for diluting hot gases between the exhaust stacks of the A unit (first) and the intake of the D unit (fourth)
2. 70 percent of the low-heat content of the fuel is expended in the harmful area, i.e., from the radiators and exhaust.
3. 100 percent of the heat radiated and exhausted from the first three units contributes to raising the ambient temperature at the intake of the D unit.

Solutions based on the second hypothesis show that the air velocity relative to the train should be at least 45 mph to give adequate cooling. Fig. 5 shows relative air velocity plotted against fan discharge for two different conditions: fan blowing against train, and fan blowing behind train. Taking 15 mph as a representative train speed, a relative velocity of 45 mph requires a fan discharge of 200,000 cfm for the case of fan-against-train, and 1,000,000 cfm for the case of fan-behind-train. These discharges, depending on the length of the train, would correspond to fan air horsepowers of about 400 and 3000, respectively.

Temperature rise at the intake of the D unit and air horsepower of piston effect for 50-car, 2500-ton, and 100-car, 5000-ton trains are plotted on Figs. 6 and 7. Also shown are three typical fan curves. Note that the temperature-rise curves fall with increasing fan discharge, while the horsepower curves rise; thus, the amount of cooling obtained is limited by the horsepower that can be expended against piston effect. Reduction in throttle position decreases temperature rise and also horsepower of piston effect, but reduces train speed.

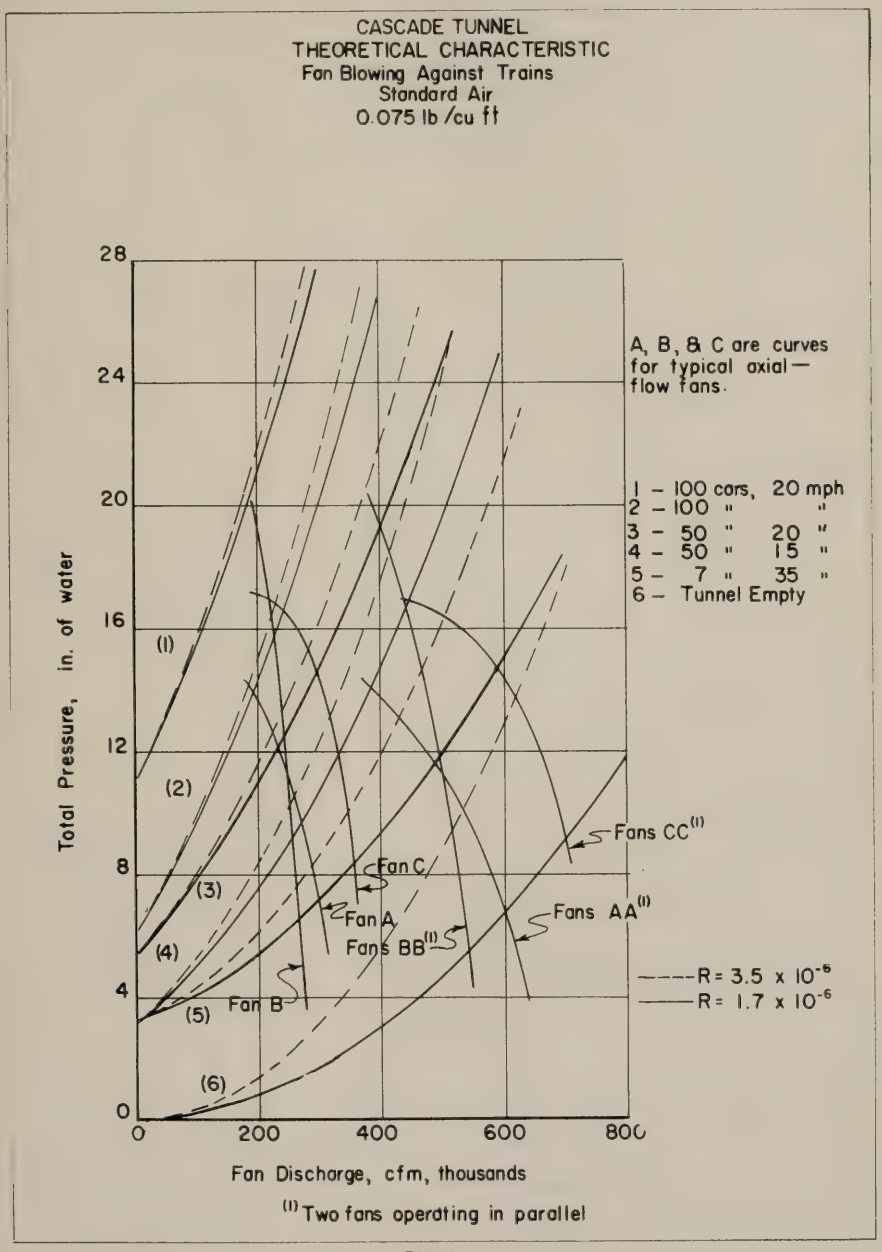
CASCADE TUNNEL
THEORETICAL CHARACTERISTIC
Fan Blowing Against Trains
Standard Air
0.075 lb/cu ft
A, B, & C are curves for typical axial—flow fans.
1 – 100 cars, 20 mph
2 – 100 " "
3 – 50 " 20 "
4 – 50 " 15 "
5 – 7 " 35 "
6 – Tunnel Empty
Total Pressure, in. of water
Fan Discharge, cfm, thousands
Fans CC(1)
Fan C
Fan A
Fans BB(1)
Fans AA(1)
Fan B
R = 3.5 x 10^-6
R = 1.7 x 10^-6
(1) Two fans operating in parallel

Fig. 1

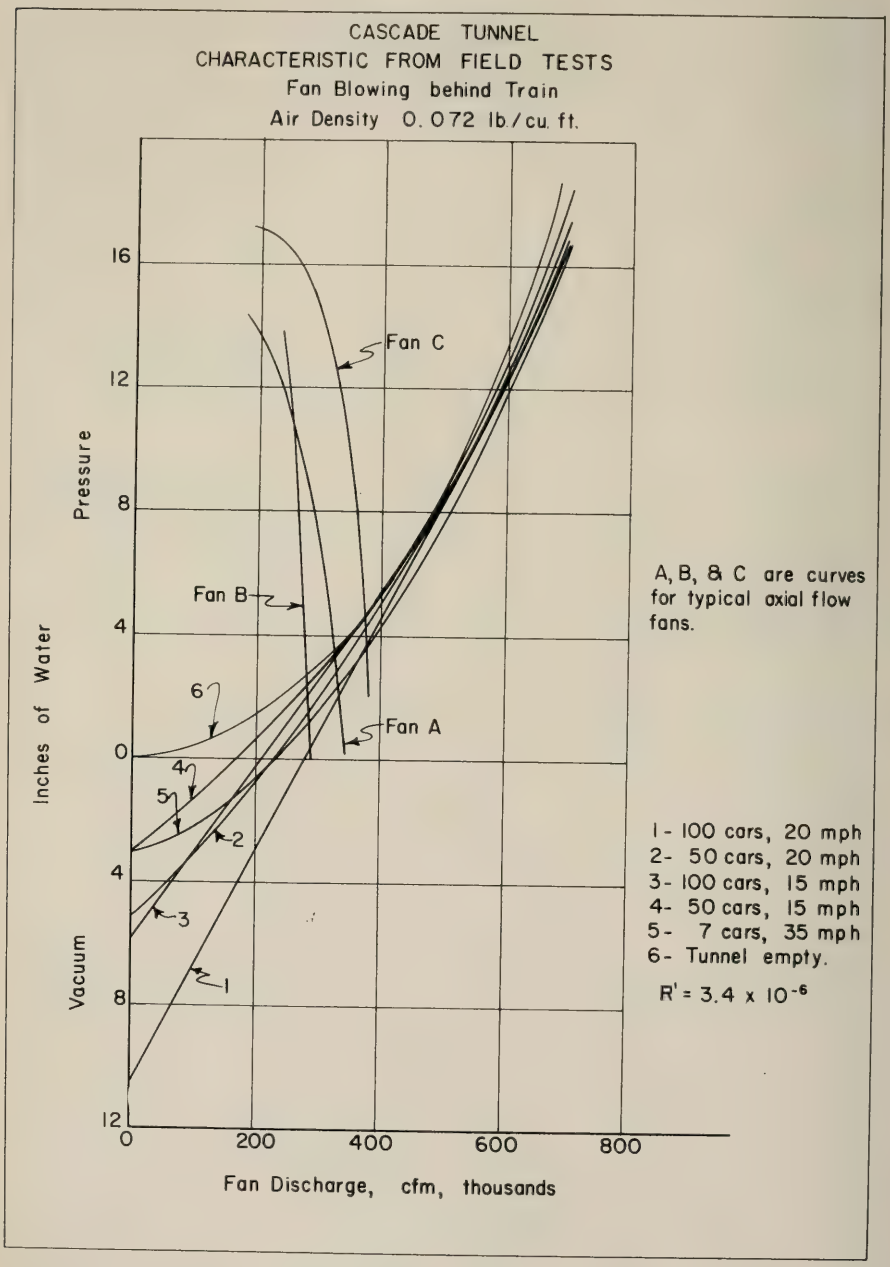
CASCADE TUNNEL
CHARACTERISTIC FROM FIELD TESTS
Fan Blowing behind Train
Air Density 0.072 lb./cu. ft.
Inches of Water
Pressure
Vacuum
16
12
8
4
0
4
8
12
0
200
400
600
800
Fan Discharge, cfm, thousands
Fan C
Fan B
Fan A
1
2
3
4
5
6
A, B, & C are curves for typical axial flow fans.
1 - 100 cars, 20 mph
2 - 50 cars, 20 mph
3 - 100 cars, 15 mph
4 - 50 cars, 15 mph
5 - 7 cars, 35 mph
6 - Tunnel empty.
R' = 3.4 x 10^-6

Figure 2

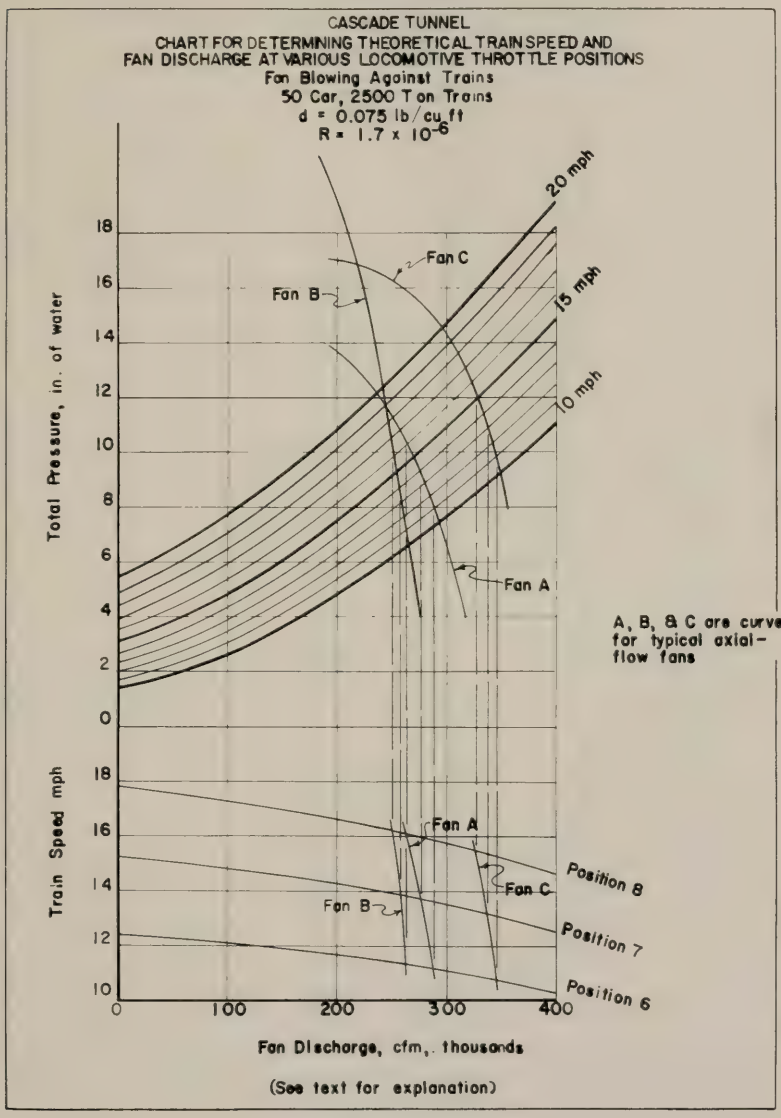
CASCADE TUNNEL
CHART FOR DETERMINING THEORETICAL TRAIN SPEED AND
FAN DISCHARGE AT VARIOUS LOCOMOTIVE THROTTLE POSITIONS
Fan Blowing Against Trains
50 Car, 2500 T on Trains
d = 0.075 lb/cu ft
R = 1.7 x 10^-6
Total Pressure, in. of water
Train Speed mph
Fan Discharge, cfm, thousands
20 mph
15 mph
10 mph
Fan A
Fan B
Fan C
Position 8
Position 7
Position 6
A, B, & C are curves for typical axial-flow fans
(See text for explanation)

Fig. 3

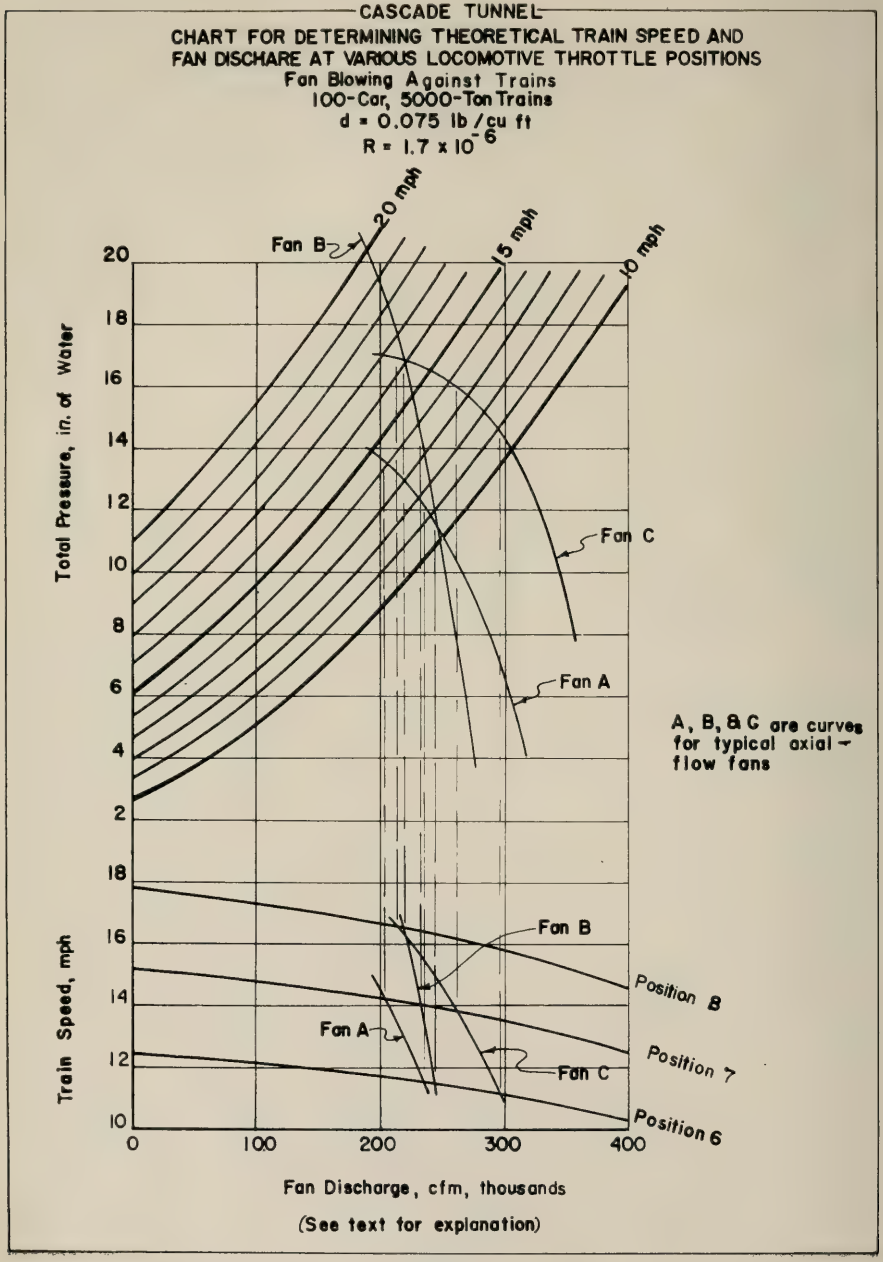
CASCADE TUNNEL
CHART FOR DETERMINING THEORETICAL TRAIN SPEED AND
FAN DISCHARE AT VARIOUS LOCOMOTIVE THROTTLE POSITIONS
Fan Blowing Against Trains
100-Car, 5000-Ton Trains
d = 0.075 lb/cu ft
R = 1.7 x 10^-6
20 mph
15 mph
10 mph
Fan B
Fan C
Fan A
A, B, & C are curves for typical axial-flow fans
Total Pressure, in. of Water
20
18
16
14
12
10
8
6
4
2
Train Speed, mph
18
16
14
12
10
Fan B
Fan A
Fan C
Position 8
Position 7
Position 6
0
100
200
300
400
Fan Discharge, cfm, thousands
(See text for explanation)

Fig- 4

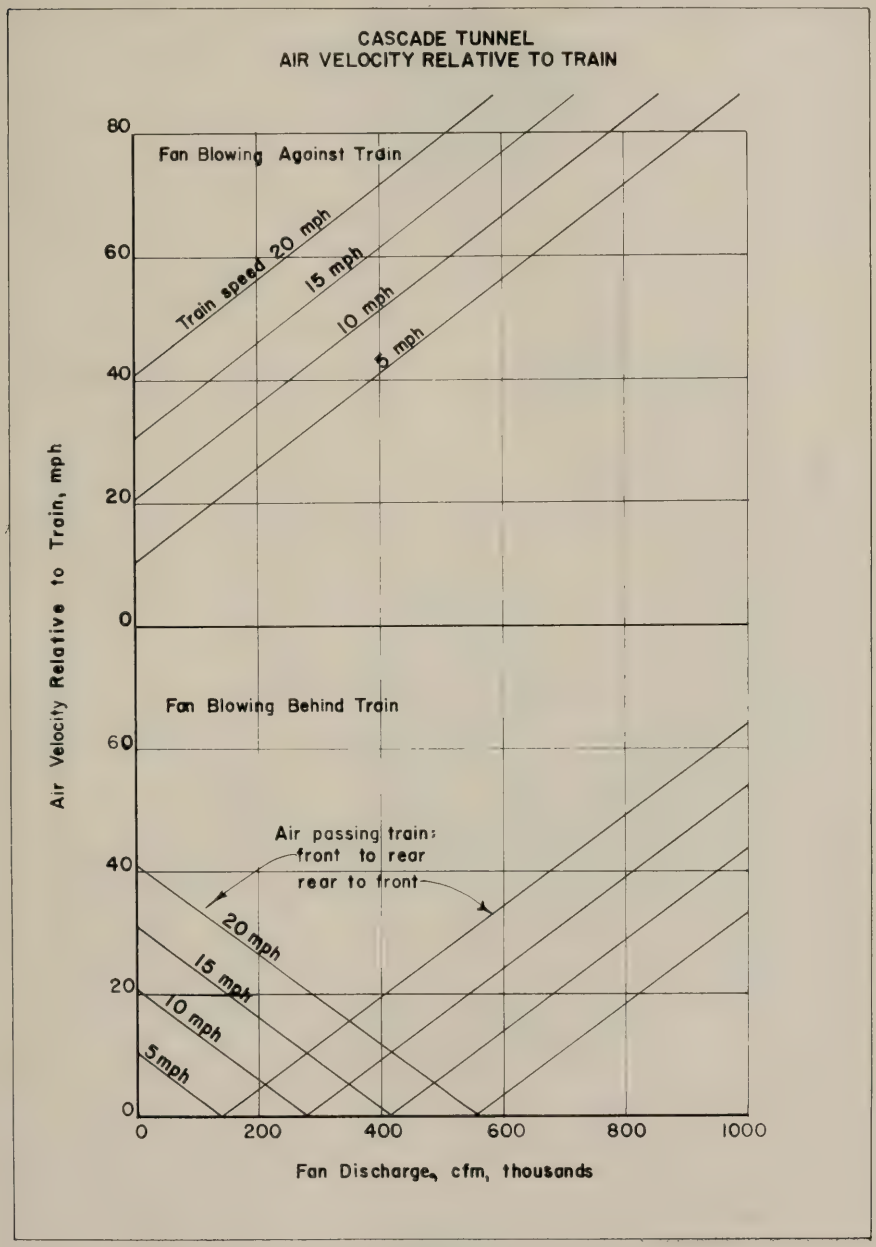
CASCADE TUNNEL
AIR VELOCITY RELATIVE TO TRAIN
Fan Blowing Against Train
Train speed 20 mph
15 mph
10 mph
5 mph
Fan Blowing Behind Train
Air passing train:
front to rear
rear to front
20 mph
15 mph
10 mph
5 mph
Air Velocity Relative to Train, mph
Fan Discharge, cfm, thousands
0
20
40
60
80
0
200
400
600
800
1000

Fig. 5

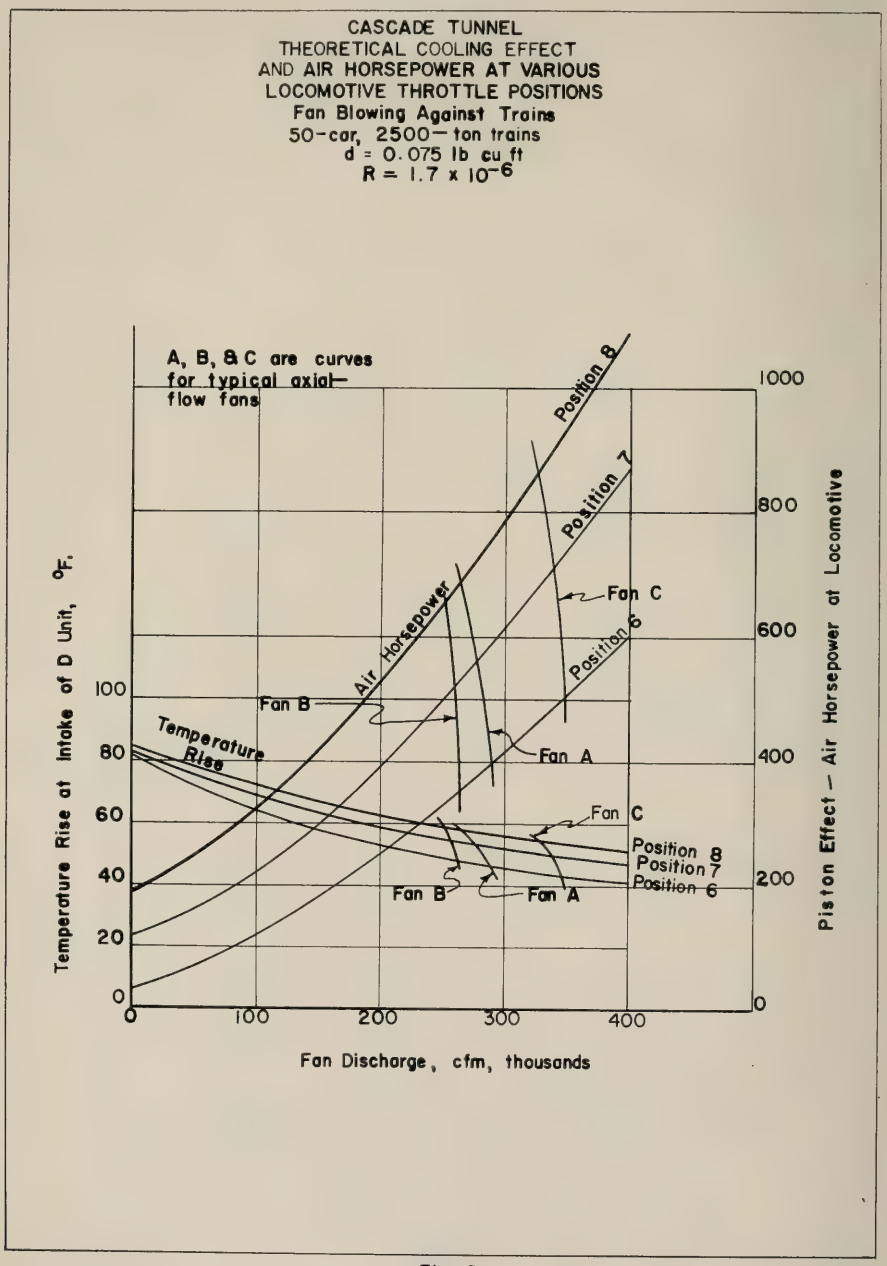
CASCADE TUNNEL
THEORETICAL COOLING EFFECT
AND AIR HORSEPOWER AT VARIOUS
LOCOMOTIVE THROTTLE POSITIONS
Fan Blowing Against Trains
50-car, 2500-ton trains
d = 0.075 lb cu ft
R = 1.7 x 10^-6
A, B, & C are curves for typical axial-flow fans
Position 8
Position 7
Position 6
Air Horsepower
Fan C
Fan B
Fan A
Temperature Rise
Position 8
Position 7
Position 6
Temperature Rise at Intake of D Unit, °F.
Piston Effect — Air Horsepower at Locomotive
Fan Discharge, cfm, thousands
0
20
40
60
80
100
0
100
200
300
400
0
200
400
600
800
1000

Fig. 6

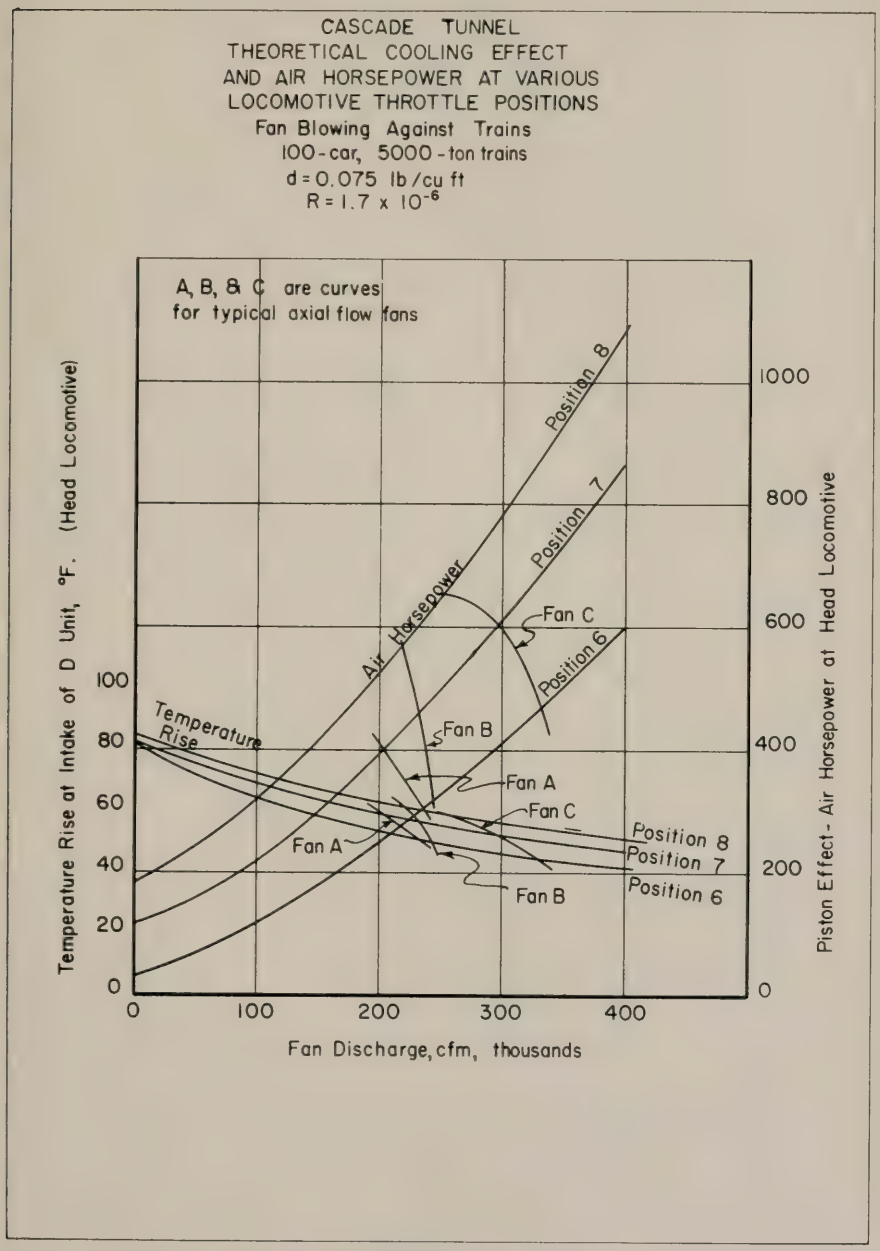
CASCADE TUNNEL
THEORETICAL COOLING EFFECT
AND AIR HORSEPOWER AT VARIOUS
LOCOMOTIVE THROTTLE POSITIONS
Fan Blowing Against Trains
100-car, 5000-ton trains
d = 0.075 lb/cu ft
R = 1.7 x 10^-6
A, B, & C are curves
for typical axial flow fans
Position 8
Position 7
Position 6
Air Horsepower
Fan C
Fan B
Fan A
Temperature Rise
Fan A
Fan C
Fan B
Position 8
Position 7
Position 6
Temperature Rise at Intake of D Unit, °F. (Head Locomotive)
Piston Effect - Air Horsepower at Head Locomotive
Fan Discharge, cfm, thousands
0
20
40
60
80
100
0
100
200
300
400
0
200
400
600
800
1000

Fig. 7

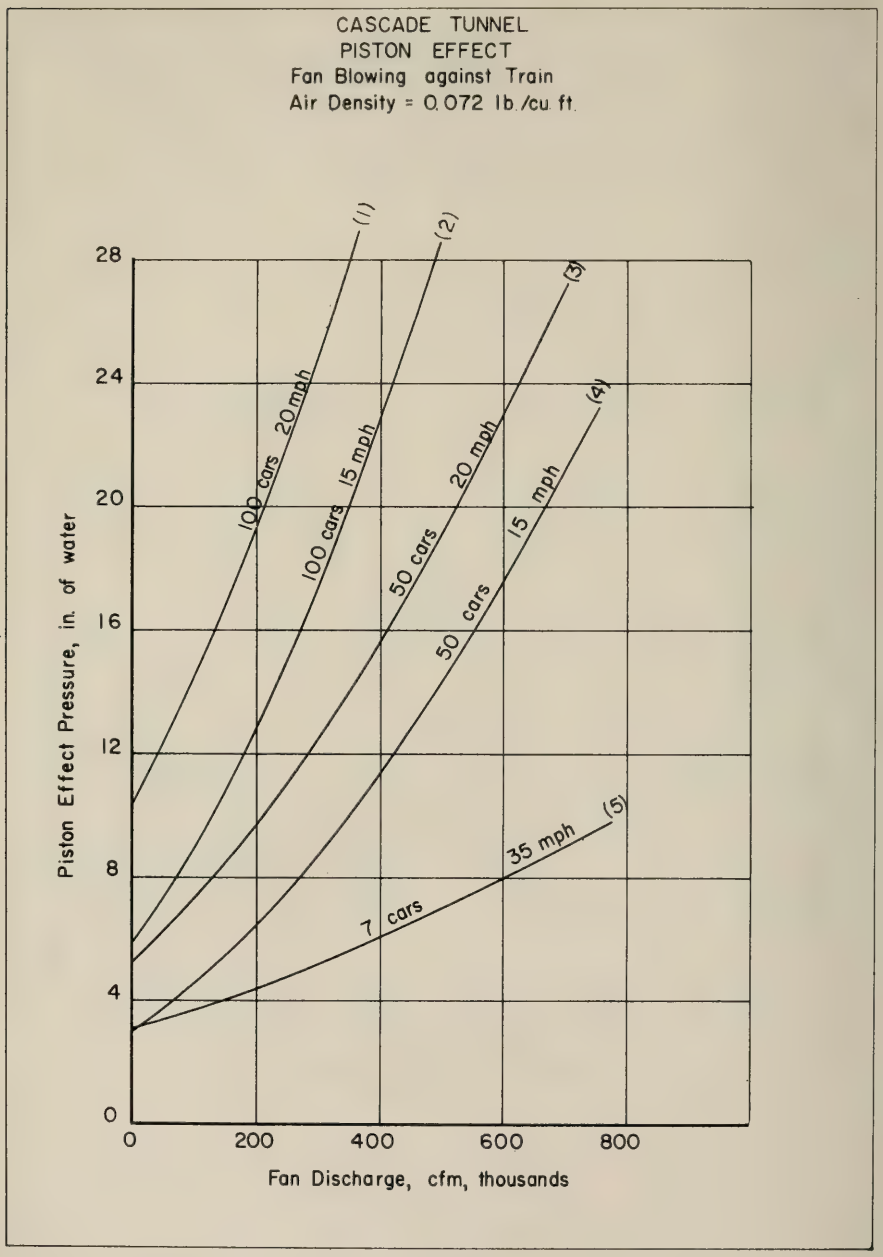
CASCADE TUNNEL
PISTON EFFECT
Fan Blowing against Train
Air Density = 0.072 lb./cu. ft.
(1)
(2)
(3)
(4)
(5)
100 cars 20 mph
100 cars 15 mph
50 cars 20 mph
50 cars 15 mph
35 mph
7 cars
Piston Effect Pressure, in. of water
0
4
8
12
16
20
24
28
0
200
400
600
800
Fan Discharge, cfm, thousands

Fig. 8

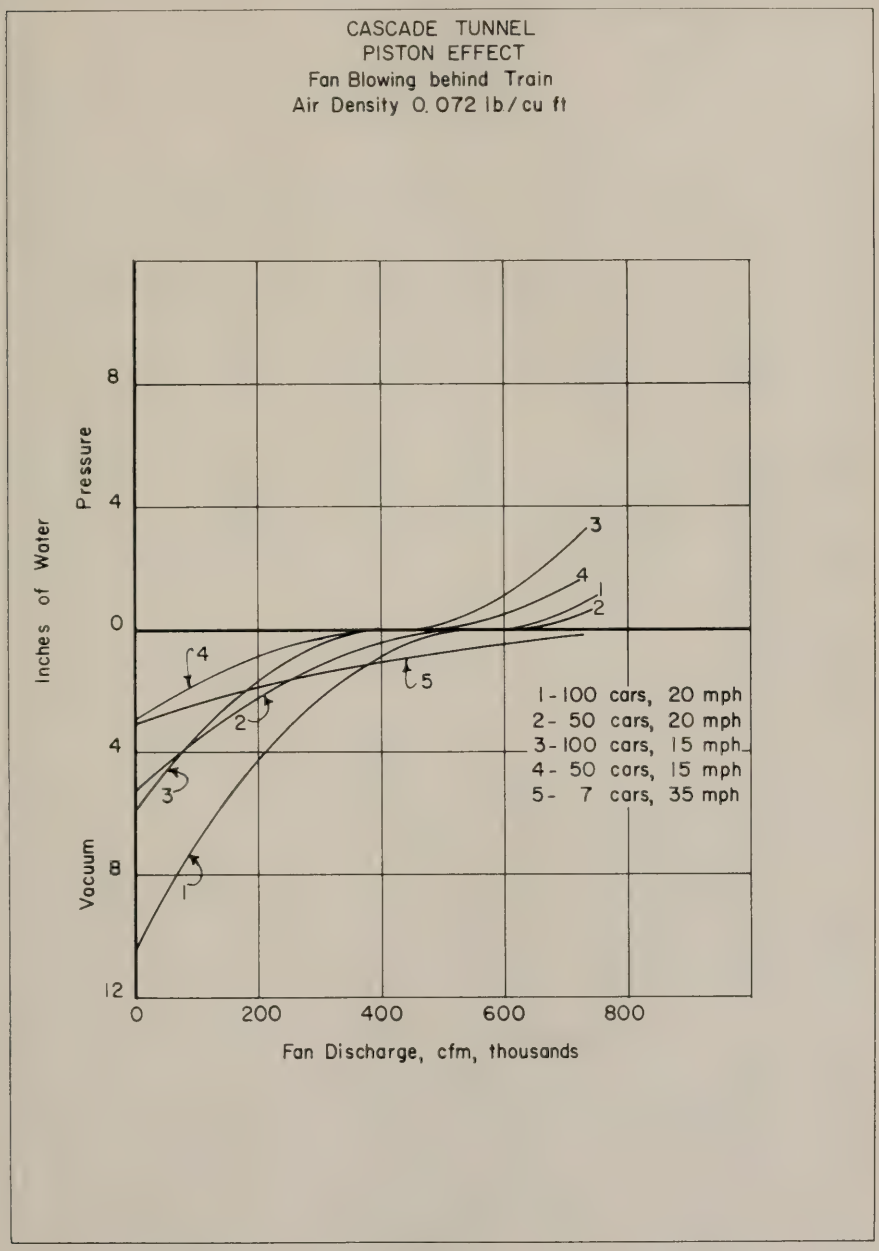
CASCADE TUNNEL
PISTON EFFECT
Fan Blowing behind Train
Air Density 0.072 lb/cu ft
Inches of Water
Pressure
Vacuum
8
4
0
4
8
12
0
200
400
600
800
Fan Discharge, cfm, thousands
1-100 cars, 20 mph
2- 50 cars, 20 mph
3-100 cars, 15 mph
4- 50 cars, 15 mph
5- 7 cars, 35 mph

Fig. 9

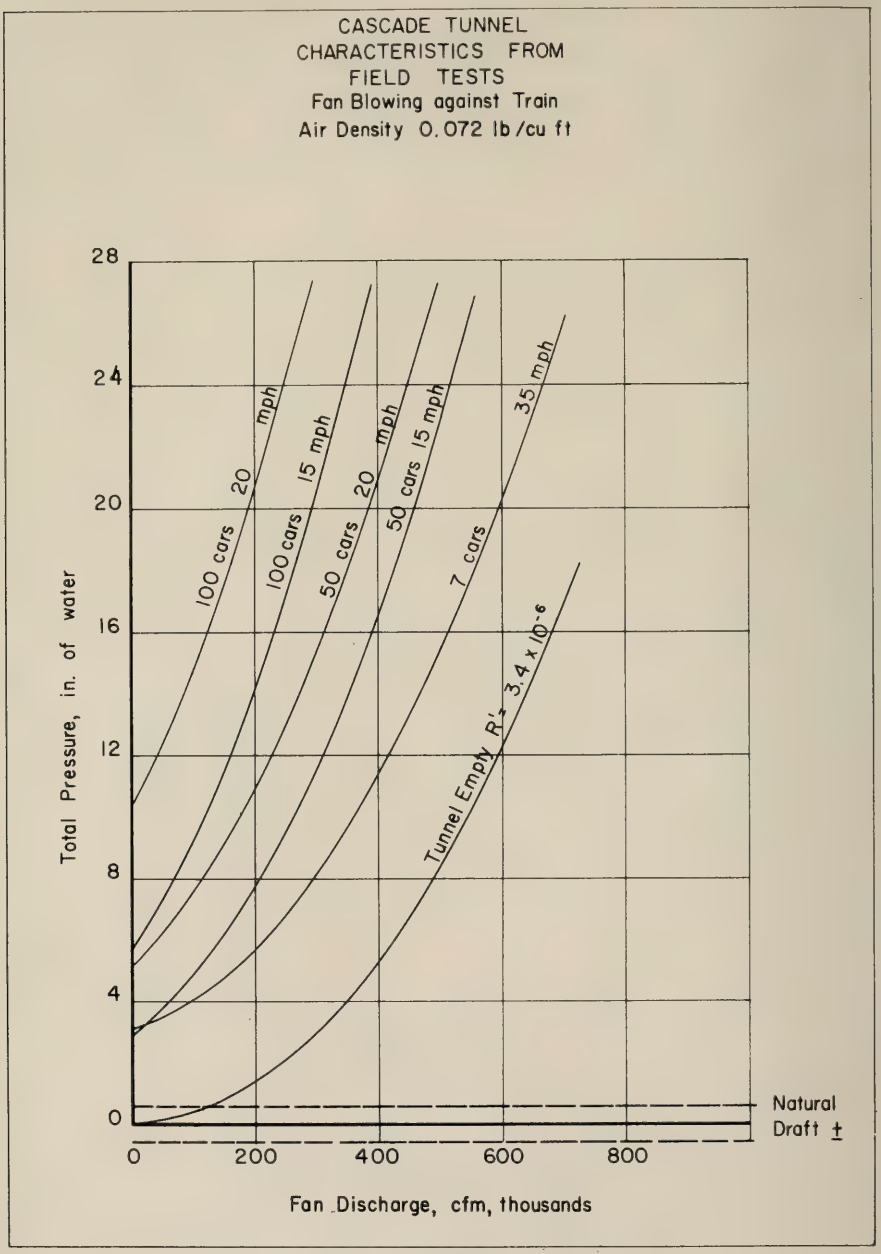
CASCADE TUNNEL
CHARACTERISTICS FROM
FIELD TESTS
Fan Blowing against Train
Air Density 0.072 lb/cu ft
Total Pressure, in. of water
28
24
20
16
12
8
4
0
0
200
400
600
800
Fan Discharge, cfm, thousands
100 cars 20 mph
100 cars 15 mph
50 cars 20 mph
50 cars 15 mph
7 cars 35 mph
Tunnel Empty R' = 3.4 x 10-6
Natural Draft ±

Fig. 10

Report on Assignment 10

Ballast

(a) Tests
(c) Special Types of Ballast

R. H. Beeder (chairman, subcommittee), E. W. Bauman, J. G. Campbell, T. T. Connelly, J. P. Datesman, A. T. Goldbeck, L. V. Johnson, E. W. McCuskey, R. L. McDaniel, W. G. Murphy, Stanton Walker, C. E. Webb.

Your committee reports this year on Assignment (c)—Special Types of Ballast. The following reports deals with asphalt ballast treatment and is part of the research sponsored by the committee on the benefits that can be obtained from this process. The special equipment developed for application is available to any Member Road of the AAR, without charge, upon application to the Research Department. The report is presented as information.

The treatment of ballast with asphalt has been studied and reported on by the Roadway and Ballast committee several times in the past. The first report in fairly recent times appears in the Proceedings, Vol. 41, 1940, page 545. This discusses 600 ft of track through the station platform at Bryan, Ohio, on the New York Central, treated in 1939 with emulsified asphalt prepared in a mixer and tamped in track under traffic to a depth of 8 in under the tie. The ties were coated by hand spray on sides and ends, and the surface was sealed with a premixed seal coat 2 in thick.

The maintenance record for this section was reported yearly from 1942 through 1945, Proceedings, Vols. 43 to 46, incl. as part of the committee's reports. The condition of the treatment was reported as satisfactory in 1944, but no further report has been published. Further investigation will be made as to the life and disposition of this section.

The ballasted-deck bridge on the New York Central near Niagara Falls, N. Y., was given a plant-mix asphalt surface, as reported in the Proceedings, Vol. 52, 1951, page 512. No further information has been developed by the committee concerning this project, which was considered satisfactory at the time of the report. This project also will be investigated to disclose its service record and present condition.

The Illinois Central project near Manteno, Ill., was constructed in 1943, using for the first time on-track application methods. The final report on this project was made after it had been in service 10 years (Proceedings, Vol. 55, 1954, page 664). Shortly after then the track was lifted out of the asphalt-penetrated ballast and has since been maintained as conventional track.

There has also been an asphalt treatment of ballast through the station platforms at South Bend, Ind., on the New York Central. This has not been reported in the AREA Proceedings but will be included in the survey.

The following data describe a new series of applications and discuss the results and economies that may follow such treatments of the track and ballast section, using specially designed equipment (See Proceedings, Vol. 60, 1959, page 712). The present work is jointly supported as cooperative research by the Asphalt Institute and the Research Department of the AAR. The project is administered by a 14-member joint committee of the Institute and the AREA, the latter representation consisting of seven members of Committee 1. The complete and excellent cooperation of the Santa Fe and the Pittsburgh & West Virginia Railways has made the work in 1959 possible. For the Institute the work has been under the direction of John M. Griffith, engineer of

TABLE 1
1959 ASPHALT TREATMENTS

	Division	Location	Miles	Weight of Rail	Year Laid	WW EW ST	Kind of Ballast	Date Last Surfaced	Width of Treatment	Gal Asphalt per Sq Yd	Penetration Asphalt	Cover Coat, Lb per Sq Yd
		Santa Fe - Ballast										
Job No. 1							Volcanic					
Test	Los Angeles	Daggett-Barstow, MP 738+4000 - MP 740+4000	2	136	1957	EW	Cinders	1957	14'	1.38	85/100	20.3 lb
Control	Los Angeles	Daggett-Barstow, MP 738+4000 - MP 740+4000	2	136	1958	EW	"	1958	-	-	-	-
Job No. 2							Volcanic					
Test	Albuquerque	Peach Springs - Truxton, MP 4728 - MP 478	5.2	136	1956	WW	Cinders	1956	14'	1.18	85/100	22 lb
Control	Albuquerque	Peach Springs - Truxton, MP 4728 - MP 478	5.2	136	1955	EW	"	1955	-	-	-	-
Job No. 3							Volcanic					
Test	Albuquerque	Suwanee-Marmon, MP 51 - MP 53	2	136	1956	EW	Cinders	1956	14'	0.99	120/150	12.5
Control	Albuquerque	Suwanee-Marmon, MP 51 - MP 53	2	136	1957	WW	"	1957	-	-	-	-
Test	Albuquerque	Suwanee-Marmon, MP 53 - MP 55	2	136	1957	WW	"	1957	14'	0.99	120/150	12.5
Control	Albuquerque	Suwanee-Marmon, MP 53 - MP 55	2	136	1956	EW	"	1956	-	-	-	-
Job No. 4										3/4 &		
Test	Eastern	Lecompton-Topeka, MP 40 - MP 44	4	115	1954	ST	B Chat	1954	14'	1.29	120/150	19.4 Slag
Control	Eastern	Lecompton-Topeka, MP 36 - MP 40	4	115	1954	ST	B Chat	1954	-	-	-	-
Job No. 5												
Test	Illinois	Bucklin-Marceline, MP 342.95 - MP 347.1	4.15	136	1957	WW	Slag	1950	14'	1.34	85/100	33.4 Gravel
Control	Illinois	Bucklin-Marceline, MP 342.95 - MP 347.1	4.15	136	1957	EW	Slag	1950	-	-	-	-
Job No. 6							Limestone					
Test	Illinois	Williamsfield-Dahinda, MP 160.5 - MP 164	3.5	136	1955	EW	Rock	1955	14'	1.24	85/100	29.8 Gravel
Control	Illinois	Williamsfield-Dahinda, MP 160.5 - MP 164	3.5	136	1955	WW	"	1956	-	-	-	-
Job No. 7						EW	Crushed			1 3/4		
Test	Los Angeles	Victorville, California, MP 34.72 - MP 35.72	2	136	1955	WW	Gravel	1956	14'	Approx.	120/150	30 lb
No Control												
Job No. 8						EE	Crushed			3/4 & 2		
Test	Los Angeles	Oro Grande, California, MP 30.1 - MP 31.35	2.5	136	1955	WW	Gravel	1956	14'	Approx.	120/150	30 lb
No Control												
Job No. 9						EE						
Test	Illinois	Monica, Illinois, MP 148.31 - MP 148.37	320'	132	1955	WW	Slag	1952	14'	3.0	85/100	50 lb
No Control												
Job No. 10						EE	Crushed					
Test	Illinois	Princeville, Illinois, MP 144.31 - MP 144.35	220'	132	1956	WW	Rock	1956	14'	1.75	85/100	15 lb
No Control												
		Pittsburgh & West Virginia Railway - Bridges										
Job No. 11			12,780'									
Test	Pennsylvania	20 Open Deck Steel Bridges	10,918 Ties						10'	1.37	60/70	33 lb
Control	Pennsylvania	Untreated Sections on Longer Bridges										

research, and R. W. Gamble, engineering consultant. For the AAR the work has been under the direction of G. M. Magee, director of engineering research, and Rockwell Smith, research engineer roadway, who prepared this report.

The tests on the Santa Fe include six treated sections and equivalent untreated control sections of comparable tonnage and track and tie conditions. These control sections are, with one exception, in the second track in double-track territory and have identical subgrade and drainage conditions. The single exception is in single-track territory where the untreated control section adjoins one end of the treated section. These sections were all inspected by representatives of the Santa Fe, the Asphalt Institute and the AAR. All sections are typical of Santa Fe track and standards (Fig. 1). All rail is welded, generally in approximately ¼-mile lengths. All asphalts are graded "asphalt cement."

The treated bridge ties on the Pittsburgh & West Virginia were also inspected and their condition recorded. Untreated sections on the longer bridges will serve as controls for future determinations of increased tie life and other possible benefits from the treatment.

Table 1 lists the projects completed in 1959.

Fig. 1—Santa Fe tracks, Peach Springs–Truxton, Ariz., prior to treatment.

Fig. 2—Asphalt treatment work train.

Santa Fe Installations Described

A short description of each Santa Fe project as completed is presented below. The planned mileage and quantities were followed in general with the exception of the quantity of cover material, which was usually increased. Also, cover was included for the one project which was originally slated to receive none. All treatments were made 14 ft wide.

In addition to the originally planned programs, four other projects were included: one mile of double track in which both tracks were treated in the vicinity of Victorville, Calif.; similar treatment of 1¼ miles of double track near Oro Grande, Calif.; a rail crossing at Monica, Ill., involving approximately 320 ft of double track; and a similar section at Princeville, Ill., involving 220 ft of track.

These sections were not included in the original test program because no similar control sections could be established. They can be considered, however, as maintenance treatments, and their record in service can be compared with their previous performance. The two California sections are through cement mill areas where flue dust was instrumental in fouling and cementing the ballast sections. The Illinois rail crossings were also sections of high maintenance cost. These four treatments are included in the following discussion. The final record of quantities is not yet available; those included herein are approximate.

Job 1—Daggett–Barstow, Calif.

This project marked the first use of the new equipment developed for the purpose (Fig. 2). Various delays were experienced, but the work was completed in two days, April 13 and 14. On this project the asphalt was applied in two applications, starting with approximately ¾ gal per sq yd. A cover coat of fine-graded volcanic cinders followed the second asphalt application. Observations a week after application indicated that the cover coat did not stick as expected. The second application with a lesser quantity of asphalt may explain to some extent this condition, but it is also to be noted that the total amount of asphalt applied was only 1.38 gal per sq yd compared with the planned amount of 1¾ gal. Full planned quantities could possibly have filled ballast voids more completely and permitted a greater surface coating to receive and hold the cover coat. The cover coat averaged 21.3 lb per sq yd. The asphalt pump was set to deliver planned asphalt quantities at a train speed of 2 mph. Variation in this speed was partially instrumental in affecting quantities. The asphalt was applied at a temperature of 350 to 400 F (Fig. 3). Fig. 4 shows the completed work.

Job 2—Peach Springs–Truxton, Ariz.

This section was treated April 24 and 25. The asphalt was applied in a single application followed immediately by the fine volcanic cinder cover. The planned 5 miles was extended 970 ft to the east to utilize all the asphalt available. This project was completed in 2 days, with 3 miles completed on the second day in the early afternoon. Average quantities over the entire length were 1.18 gal of asphalt per sq yd and 22 lb of cinders. The asphalt, applied at temperatures between 300 and 380 F.

Job 3—Suwanee–Marmon, N. M.

This project, treated on April 27 and 28, was originally planned for no cover coat, as the ballast included a quantity of blow sand and fine cinders. From previous observations, however, the cover coat was indicated and was applied. The project extends from MP 51–53 on the eastward main and from MP 53–55 on the westward main. The untreated control sections are directly opposite the treatments. This split in the

Fig. 3—Asphalt spray.

Fig. 4—Completed asphalt treatment.

project was deemed advisable to balance the ballast condition, as one track is subject to a greater amount of blow sand from surrounding areas.

Asphalt was applied in a single pass at a temperature of 350 to 380 F. Quantities for the project averaged 0.99 gal of asphalt and 12.5 lb of cinder cover per square yard.

Job 4—Lecompton–Topeka, Kans.

This section, treated on May 14 and 15, is on single track and is 4 miles long. The entire distance is ballasted with coarse chat except for a ¾-mile stretch which was given a final surface of fine chat. The control section, untreated, is adjacent to the east.

Average asphalt application over the coarse chat was 1.29 gal per sq yd, over the fine chat, ¾ gal per sq yd. The cover coat was fine slag averaging 19.4 lb per sq yd for the full treatment. Asphalt cement with 150/200 penetration was used on this project.

Job 5—Bucklin–Marceline, Mo.

Treated May 19 and May 29, this project extends from MP 342 + 5030 to 347 + 500, a distance of 4.1 miles. This varies slightly from the planned limits and length. On May 19, 1959, 2¼ miles were completed. On May 20 a failure in the distributor car heating system occasioned long delay and resulted in asphalt temperatures below 300 F. As commitments had been made for the Illinois project to start on May 21, work at this location was postponed, and the asphalt shipped to the shops for steam heating. Work was completed on May 29.

Asphalt coverage on this project averaged 1.34 gal per sq yd with the cover ballast averaging 33.4 lb per sq yd. Gravel screened to produce a material with 100 percent passing a ½-in screen was used as the cover coat (Fig. 5). Much of the material was wet, but observations indicated that this had no apparent effect on the quantity sticking to the ties and ballast. A heavy rain early on May 19 produced wet conditions not favorable for asphalt work. At 10:30 am, however, sufficient drying had occurred to permit start of treatment. Asphalt was applied at 315 to 350 F.

Job 6—Williamsfield–Dahinda, Ill.

Treated May 21 and 22. Three and one-half miles were completed on May 21 with the exception of 0.2 miles of cover ballast, which was applied May 22. Delays in dead-heading the equipment and switching rather than operational delays forced a close-down under the 16-hr requirement for the work-train crew. The actual time for the ballast treatment, including reloading and car switching was less than 8 hr. Project limits as treated are MP 160.5 to 164, ½ mile less than planned.

Work on May 21 included the asphalt application over the above limits. The gravel cover coat was stopped at MP 160.7 with the depletion of the material in the spreader car. Asphalt application was continued to MP 160.5 to empty the tank. The cover coat was applied the next day in a steady cold rain. The asphalt supply had cooled to 275 F, too low for operation in the rain, and the project was decreased in length the half mile as noted.

Inspection of this project four months later indicated that it was in excellent shape. The joining of tie and ballast in the cribs was tight, there had been no apparent movement of the rails or ties and the track line remained excellent. The gravel cover which had been spread in the rain on cold asphalt adhered surprisingly well to the ties and ballast. The asphalt was applied at temperatures of 300 to 325 F.

Quantities per square yard for the treatment averaged 1.24 gal and 29.8 lb of fine gravel cover

Fig. 5—Spreader car applying cover ballast to asphalt treatment.

Fig. 6—View showing overhead suction line from tank car to distributor.

Victorville, Calif.—Project Treated April 15 and 20, 1959

As mentioned previously, this section of track was treated to alleviate fouling conditions produced by dust from the adjacent cement plant. The ballast is crushed gravel with over 80 percent of the particles showing two or more fractured faces. Maximum size of particles is about 1½ in. The ballast section was rather open and lacking in fines, so the proposed treatment was set at 1¾ gal of asphalt per square yard with 30 lb or more of crushed gravel passing a ½-in sieve for the cover coat.

The asphalt cement came in the 120/150 penetration range and was distributed in two passes at 0.75 gal and 1.0 gal per sq yd, with the second application followed immediately by the cover coat. At 2 mph the asphalt pump capacity is in effect limited to a spread of 1½ gal per sq yd over a 14-ft width with $\frac{3}{16}$-in nozzles. A slower speed would result in greater coverage but is hard to control without special devices on the locomotives.

On April 15 work was completed on 1 mile of the westward track, and on ⅓ mile of the eastward. In addition, the first application of asphalt was applied to the remainder of the eastward. Track time for the day was limited to about 2 hr because of traffic. Production was good for the time available.

There was no work on April 16. Suction lines to the distributor failed as did the car air compressor, and the equipment was returned to the shop for repairs (Fig. 6). The job was completed on April 20 with the second application of asphalt and the cover coat on the remaining ⅔ mile.

Average quantities for the project are not yet available.

Oro Grande, Calif.—Project Treated April 20, 1959

This project was started and completed on April 20. It involved 1¼ miles on each track with asphalt applied at 2 gal per sq yd on the eastward main and at 1¾ gal on the westward main, both quantities spread in two applications. The cover coat of fine crushed gravel was placed at a rate of 30 lb per sq yd.

The conditions of ballast, cement-mill dust and track were comparable to the Victorville project. Final quantities are not yet available. Considerable amounts of the cover coat on both projects were whipped off by traffic.

Monica and Princeville, Ill.—Rail Crossing Projects—Treated June 4, 1959

These two small treatments are grouped as one as they were applied in sequence for each track. The project involved 320 ft of double track at Monica and 220 ft at Princeville. These treatments also may be regarded as maintenance, as no comparable untreated control sections are available for direct comparison.

Asphalt was applied to the eastward main at Monica in two applications totaling 3 gal per sq yd, with two applications of fine gravel cover totaling 50 lb per sq yd. One application of asphalt, 1¾ gal per sq yd, was placed on the westward main with one application of cover stone at 20 lb per sq yd. This latter treatment was also made to both tracks at the Princeville crossing. Asphalt was applied at 335 F.

Work on the Pittsburgh & West Virginia Railway

On November 12 and 13, 1959, this road treated 12,780 ft of open-deck steel bridges (10,918 ties on 20 bridges) with a hot application of 60/70 penetration asphalt cement followed by a spread of slag screenings with maximum size of ½ in. The treatment with one exception was over a 10 ft width. One length of 700 ft was treated over a width of 14 ft, including walkway. Fig. 7 is a view of the completed work on one bridge.

Fig. 7—Pittsburgh & West Virginia asphalt treated bridge deck.

Fig. 8—Close-up view of treated bridge deck.

This treatment was designed as a bridge tie preservation measure (Fig. 8) and is not properly the concern of the Roadway and Ballast committee. It is reported here briefly as of special interest with the probability that a full report will be made by the proper committees. The ties were all inspected by the railroad and the AAR staff prior to treatment and on the longer bridges an untreated section was left as a control. Asphalt was applied at 350 to 370 F.

Conclusions

The early work with the present equipment was completed satisfactorily but showed up a number of deficiencies in the equipment. These were remedied specifically by jacketing the center spray bar to permit heating with the hot oil circulating system, the heating capacity of which was also stepped up. The compressor for raising the intake booms was increased in size, and new suction hoses of a more flexible nature with metal spiral reinforcement were installed. On the P&WV these hoses collapsed under the suction, and the original flexible metallic hoses were used. This resulted in a very appreciable delay in tracing the cause. These improvements in general, however, gave much more definite control, and after the start of the bridge work the application was efficient and positive.

Quantities of asphalt and cover coat can be controlled within narrow limits. The speed of the work train is the determining factor in controlling yield of materials as planned.

The equipment has a potential of five miles per day. The bottleneck in production is the material supply, particularly the cover-coat material. The spreader car has been altered to hold approximately 90 tons in work-train service, which, for the usual treatment, will be sufficient for one tank car of asphalt and approximately one mile. The distributor car can draw from either or both of two tank cars, and with sufficient cover ballast would double the possible application yardage without a break for reloading.

Quantites of both asphalt and cover coat for a project are dependent to a considerable extent on the gradation and tightness of the track ballast. The finer graded materials will usually require less. This also affects the penetration. For the 1959 tests the penetration varied from 1 in to 3 in with the lesser depth on the finer graded ballasts.

The asphalt used during the 1959 program was asphalt cement of low to moderately high penetration—60/70 to 120/150. This requires a temperature, for efficient spraying, of 280 F or more, depending to some extent on the temperature viscosity properties of the material being used. Viscosities in the range of 25 to 100 seconds Saybolt Furol are satisfactory. Other types of asphalt, such as emulsions and cut-backs, should also prove satisfactory for ballast treatment and will be used as the investigation proceeds. These will lessen heating requirements appreciably but will result in a higher material cost for equal asphalt content.

Sufficient time has not elapsed since treatment to permit an appraisal of the possible benefits. However, the asphalt ballast treatments have been reported as satisfactory to date. Great benefits are expected from increased tie life and prevention of ballast fouling, in addition to other savings in reducing lining and surfacing. The costs of the treatments have ranged from approximately $900 per mile for ballast treatment to $1800 per mile for the bridge work. Asphalt cement costs have varied from $0.05 to $0.105 per gal, including freight where applicable. It seems possible to spray and cover the bridges at about $1500 per mile and the ballast section at an average of approximately $1300. Increased daily production will lower costs appreciably.

A report received from a maintenance officer of the Santa Fe is quoted, as follows: "So far as sealing of the entire ballast section is concerned, we are fully convinced that

particularly in selected locations such as our Victorville and Oro Grande areas, which were chronic trouble spots because of cement dust from nearby cement plants infiltrating into the crushed rock ballast, also in sand blown territory, that the asphalt treatment will more than prove its worth in a short period of time. We also believe that the life of the ties will be increased. We have noted while passing over the asphalt-treated territory on trains that noises from beneath the cars are decreased."

Report on Assignment 11

Chemical Control of Vegetation

Collaborating with Signal Section and Communications Section, AAR

C. E. Webb (chairman, subcommittee), C. R. Bergman, T. T. Connelly, R. J. Kemper, P. G. Martin, S. J. Owens, A. J. Pacelli, A. C. Parker, Jr., W. O. Trieschman.

This report, presented as information, consists of two parts. Part 1 is a report on vegetation control research at North Carolina State College prepared by Dr. G. C. Klingman and Merrill Wilcox of that institution. This report completes the planned and sponsored research at North Carolina State College.

Part 2 is the report of the AAR research staff on the field studies conducted during 1959. It was prepared by C. G. Parris, agronomist, and Rockwell Smith, research engineer of roadway.

This work, sponsored by the committee, has been conducted by the Research Department, AAR, under the general direction of G. M. Magee, director of engineering research, and under the supervision of Rockwell Smith. C. G. Parris conducted the field studies.

Part 1—Railroad Weed Control, North Carolina State College

By Glenn C. Klingman and Merrill Wilcox[1]

Most of the Eastern United States has adequate rainfall and a long enough growing season to produce heavy plant growth. This is especially true in the Southeast. When trees are removed, brush, woody vines, and strong perennial grasses soon infest the area. In addition, there is sufficient rainfall to quickly leach most soil sterilants from the soil. For these reasons, vegetation control on the roadbeds is particularly difficult. Bermuda grass *(Cynodon dactylon)* is one of the most difficult plants in the Southeast to control in the roadbed. Therefore this plant was chosen for special consideration in the program.

The Research Department of the Association of American Railroads, North Carolina State College, the Durham & Southern Railway and the Norfolk Southern Railway have cooperated in a weed control research program conducted through the years 1957, 1958, and 1959. The results at the end of the first season were reported as Part 2 of the report on Chemical Control of Vegetation, Committee 1—Roadway and Ballast, AREA Proceedings, Vol. 59, 1958, pages 843–850. The results for the second season appear in the same publication, Vol. 60, 1959, pages 723–732.

Two areas were chosen for the research programs. The Norfolk Southern roadbed located in the suburbs of Charlotte, N. C., was heavily infested with Bermuda grass

[1] Professor of field crops and graduate assistant, respectively, North Carolina State College, Raleigh, N. C.

Fig. 1—General view of the Charlotte track as it appeared prior to spray treatment in 1957.

(Fig. 1). The roadbed is underlain by cinders, and considerable coarse sand has been added in the last few years.

The Durham & Southern roadbed between Holly Springs and Apex was lightly but rather uniformly infested with Bermuda grass. In addition, it had a rather heavy infestation of woody plants, including cowitch vine *(Campsis radicans),* poison ivy *(Rhus toxicodendron),* and blackberry *(Rubus spp.).* The roadbed is composed of coarse crushed granite. Cinders have not been used for many years.

Each plot was 4 rail lengths long and 16½ ft wide. This width covers 1 acre per ½ mile, or 2 acres per mile. Each treatment was replicated three times. Sprays were applied with a spray boom mounted on a small push car drawn by a motor car.

The chemicals were applied on the dates, at the rates, and in the amount of spray mixture shown in Tables 1 and 2. Where practical, chemical rates are given and discussed in this paper in terms of active ingredient per acre. This was not possible in certain mixtures such as the granular materials. As indicated in the tables, most treatments were continued for three years on the same plot areas. Changes that were made are indicated in Tables 1 and 2. The amount of spray mixture was normally 33 gal per acre or 66 gal per mile unless there was a specific need for larger amounts. The chemicals used, the trade name, and the company providing the chemical are shown in Table 3.

Results of the control were rated annually, using a rating of 10 for 100 percent control and 1 for no control. In addition, pictures were taken of one complete replication each year.

(Text continued on page 731)

TABLE 1. CHARLOTTE, NORTH CAROLINA - NORFOLK SOUTHERN RAILWAY

Treat No.	Chemicals,[1] July 17, 1957	Rates Per Acre (Lbs or Gal. Active Ingredients) and Dates of Application: August 7, 1957	June 4, 1958	July 9, 1958	June 5, 1959	July 6, 1959	Gal Spray	Weed Control Ratings,[2] Sept 10, 1959: Broad-leaved	Annual Grasses	Perennial Grass	Average
1	Dalapon 10	Dalapon 10	*	*	*	*	33	5.0	6.0	6.3	[illegible]
2	Dalapon 40 2,4-D 8	None	*	*	*	*	33	[illegible]	[illegible]	[illegible]	[illegible]
3	Dalapon 20 2,4-D 4	Dalapon 20 2,4-D 4	*	*	*	*	33	6.0	[illegible]	[illegible]	6.7
4	Dalapon 10 2,4-D 2	Dalapon 10 2,4-D 2	*	*	*	*	33	7.5	7.0	6.7	[illegible]
5	Dalapon 10 2,4-D 2 Diuron 10	Dalapon 10 2,4-D 2	*	*	*	*	33	9.0	9.3	8.7	[illegible]
6	Dalapon 10 2,4-D 2 Simazin 10	Dalapon 10 2,4-D 2	*	*	*	*	33	[illegible]	[illegible]	9.0	[illegible]
7	Dalapon 10 2,4,5-T 2	Dalapon 10 2,4,5-T 2	*	*	*	*	33	4.7	6.0	[illegible]	[illegible]
8	Dalapon 10 2(2,4,5-T)P 2	Dalapon 10 2(2,4,5-T)P 2	*	*	*	*	33	6.7	[illegible]	[illegible]	[illegible]
9	Dalapon 10 PBA(354) 4	Dalapon 10 PBA(354) 4	*	*	*	*	33	[illegible]	[illegible]	[illegible]	[illegible]
10	Dalapon 10 Diuron 10	Dalapon 10	*	*	*	*	33	[illegible]	10.0	9.7	[illegible]
11	AT 5 PBA(354) 4	AT 5 PBA(354) 4	AT 5 PCP 5	AT 5 PCP 5	*	*	33	[illegible]	[illegible]	[illegible]	[illegible]
12	AT 5 PBA(354) 4 Simazin 16	AT 5 PBA(354) 4	AT 5 Simazin 20	None	AT 5 Simazin 10	None	33	9.0	8.7	10.0	[illegible]
13	AT 5 2,4-D 2	AT 5 2,4-D 2	TCE 2 AT 5	TCE 2 AT 5	Dalapon Ester 20 Fenac 4	Dalapon Ester 20 Fenac 4	33	7.7	6.0	3.7	[illegible]
14	AT 5 Dalapon 19	AT 5 Dalapon 20	*	*	*	*	33	[illegible]	[illegible]	6.7	[illegible]
15	Conoco 100	None	*	*	*	*	100	[illegible]		[illegible]	[illegible]
16	Agronyl 100	None	*	*	*	*	100	[illegible]	[illegible]	[illegible]	[illegible]
17	Agronyl 100 Simazin 10	None	Conoco 10 Simazin 20	None	*	*	100	[illegible]	[illegible]	[illegible]	
18	Agronyl 100 Diuron 10	None	Conoco 10 Diuron 10	None	*	*	100	[illegible]	[illegible]	[illegible]	[illegible]
19	Agronyl 48 HCA 2 gal	Agronyl 48 HCA 2 Gal	Conoco 1 HCA 2 Gal	Conoco 17 HCA 2 Gal	*	*	50		[illegible]	[illegible]	[illegible]
20	Agronyl 43 PBA(103A) 10	Agronyl 43 PBA(103A) 10	Conoco 1 PBA MIX 10	Conoco 1 PBA 10	*	*	50	[illegible]	[illegible]	[illegible]	[illegible]
21	Agronyl 43 Mon-TCA 21	Agronyl 43 Mon-TCA 21	Conoco 1 *	Conoco 1 *	*	* *	50	[illegible]	[illegible]	[illegible]	[illegible]
22	Fen-TCA 21	Fen-TCA 21	*	*	*	*	[illegible]	[illegible]	7.7	[illegible]	[illegible]
23	Chlorax Liq 100 Diuron 10	None	*	*	*	*	100	10.0	10.0	10.0	[illegible]
24	Chlorax Liq 50 Diuron [illegible]	Chlorax Liq 50 Diuron [illegible]	*	*	*	*	50	9.7	10.0	10.0	[illegible]
25	Monsanto 10847 20	Monsanto 10847 20	Herb NP-A 1 [illegible] Gal/A	Herb NP-A 1 [illegible] Gal/A	*	*	33	[illegible]	[illegible]	[illegible]	[illegible]
26	Monsanto 13842 20	Monsanto 13842 20	FBC 2 Atrazine 10	FBC 2 Atrazine 10	*	*	33	9.0	9.0	[illegible]	[illegible]
27	Erbon 120	None	*	*	*	*	[illegible]	[illegible]	10.0	[illegible]	[illegible]
28	Diuron 40	None	*	*	Diuron [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]
29	Simazin 40	None	*	*	Simazin 20	None	40	10.0	10.0	[illegible]	[illegible]
30	Urea-bor 872	None	*	*	Urea-bor 10	None	[illegible]	[illegible]	10.0	9.7	[illegible]
31	Chlorea 872	None	*	*	Chlorea 10	None	[illegible]	[illegible]	10.0	[illegible]	[illegible]
32	Sodium Chlorate 2,4-D 872	None	*	*	*	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
33	Check	Check	Atrazine 20	None	*	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34	Check	Check	RHR 45 Gal/A	RHR 45 Gal/A	*	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	Check	Check	Check	Check	Check	Check	None	1.0	1.0	1.0	1.0

[1] See Table 3 "Chemicals Used"
[2] Weed Control Ratings - 10 - Perfect Control, 1 - No Control
* Treatments the same as the preceding year

Least Significant Difference (.05) [illegible]
Least significant Difference (.01) [illegible]
Coefficient of Variability [illegible]

TABLE 2. HOLLY SPRINGS, NORTH CAROLINA - DURHAM AND SOUTHERN RAILWAY COMPANY

Treat No.	Chemicals,[1] Rates Per Acre (Lb or Gal Active Ingredients) and Dates of Application: May 10, 1957	June 6, 1957	May 19, 1958	June 23, 1958	May 27, 1959	June 22, 1959	Gal Spray	Weed Control Ratings,[2] Sept. 10, 1959: Broad-Leaved	Annual Grasses	Bermuda Grass	Average
1	Dalapon 10	Dalapon 10	*	*	*	*	33	5.3	9.3	7.7	7.1
2	Dalapon 10 2,4-D 8	None	*	*	*	*	33	6.7	8.0	8.7	7.8
3	Dalapon 20 2,4-D 4	Dalapon 20 2,4-D 4	*	*	*	*	33	7.7	8.7	9.3	8.6
4	Dalapon 10 2,4-D 2	Dalapon 10 2,4-D 2	*	*	*	*	33	7.0	8.0	8.3	7.8
5	Dalapon 10 2,4-D 2 Diuron 10	Dalapon 10 2,4-D 2	*	*	*	*	33	8.3	9.7	10.0	9.3
6	Dalapon 10 2,4-D 2 Simazin 10	Dalapon 10 2,4-D 2	*	*	*	*	33	7.0	9.7	9.3	8.7
7	Dalapon 10 2,4,5-T 2	Dalapon 10 2,4,5-T 2	*	*	*	*	33	7.7	8.7	7.7	8.0
8	Dalapon 10 2(2,4,5-T)P 2	Dalapon 10 2(2,4,5-T)P 2	*	*	*	*	33	7.3	8.0	6.3	7.2
9	Dalapon 10 PBA(354) 4	Dalapon 10 PBA(354) 4	*	*	*	*	33	9.0	9.7	6.7	8.3
10	Dalapon 10 Diuron 10	Dalapon 10	*	*	*	*	33	6.0	9.7	10.0	8.6
11	AT 5 PBA(354) 4	AT 5 PBA(354) 4	None	AT 5 PCP 6	AT 5 PCP 6	AT 5 PCP 6	33	6.0	3.7	3.0	4.9
12	AT 5 2,4-D 2	AT 5 2,4-D 2	AT 5 TCA 20 Diuron 20	None	*	*	33	8.0	10.0	10.0	9.3
13	None	Agronyl 100	Agronyl 100	None	*	*	100	5.3	6.0	4.0	5.1
14	None	Conoco 100	Conoco 100	None	*	*	100	5.3	5.7	4.3	5.1
15	Agronyl 48 HCA 2 Gal	Agronyl 48 HCA 2 Gal	Conoco 47 HCA 3 Gal	Conoco 47 HCA 3 Gal	*	*	50	7.7	9.7	8.7	8.7
16	Agronyl 48 HCA 2 Gal Simazin 10	Agronyl 48 HCA 2 Gal	Conoco 47 HCA 3 Gal Simazin 10	Conoco 47 HCA 3 Gal	*	*	50	7.0	9.3	9.7	8.7
17	Agronyl 45 PBA(103A) 10 Simazin 10	Agronyl 45 PBA(103A) 10	Conoco 45 PBA(94A) 10	Conoco 45 PBA(94A) 10	*	*	50	9.3	10.0	9.3	9.3
18	Agronyl 43 Mon-TCA 21	Agronyl 43 Mon-TCA 21	Conoco 46 1/2 Mon-TCA 10 1/2	Conoco 46 1/2 Mon-TCA 10 1/2	*	*	50	7.7	10.0	10.0	9.2
19	Fen-TCA 21	Fen-TCA 21	Fen-TCA 10 1/2	Fen-TCA 10 1/2	*	*	33	9.0	9.7	8.7	9.1
20	Chlorax Liq 100 Diuron 10	None	*	*	*	*	100	7.7	10.0	10.0	9.2
21	Chlorax Liq 50 Diuron 5	Chlorax Liq 50 Diuron 5	*	*	*	*	50	8.0	10.0	10.0	9.3
22	Monsanto 9303 40	None	Herb NP-AT 165 Gal/A	Herb NP-AT 165 Gal/A	*	*	33	8.3	9.3	9.0	8.9
23	Monsanto 9303 20	Monsanto 9303 20	FB-2 2 Atrazine 10	FB-2 2 Atrazine 10	*	*	33	8.0	9.7	9.3	9.0
24	Erbon (Baron) 120 (30 Gal)	None	Erbon 60	None	*	*	33	8.0	9.3	10.0	9.1
25	Diuron 40	None	*	*	*	*	33	7.3	10.0	10.0	9.1
26	Simazin 40	None	*	*	*	*	33	7.0	9.7	9.0	8.6
27	Ureabor 872	None	Ureabor 436	None	*	*	Gran	9.0	9.7	10.0	9.6
28	Chlorea 872	None	Chlorea 436	None	*	*	Gran	8.0	10.0	10.0	9.3
29	Sodium Chlorate -2,4-D 872	None	Sodium Chlor- ate-2,4-D 436	None	*	*	Gran	8.3	9.3	10.0	9.2
30	Check	Check	Check	Check	Check	Check	None	1.0	1.0	1.0	1.0

Least Significant Difference (.05)	1.8	1.0	1.3
Least Significant Difference (.01)	2.4	1.1	1.9
Coefficient of Variability	.159	7.	11

[1]See Table 3 "Chemicals Used"
[2]Weed Control Ratings - 10 = Perfect Control, 1 = No Control
*Treatments the same as the preceding year

Error in 1959 - Simazine (40 Lb/Acre) applied to Ureabor plots in Reps 2 and 3 (plots 15 and 74) on May 25.

TABLE 3. CHEMICALS USED

Chemical	Active Ingredient	Trade Name	Provided By
Dalapon	71	Radapon	Dow Chemical Company
TCA	90%	TCA Grasskiller	Amchem Products, Inc.
TCI-Trichloro isobutyric Acid	2 Lb/Gal	ACP M540	Amchem Products, Inc.
PCP (Emuls.)	1 Lb/Gal	ACP M604	Amchem Products, Inc.
HCA	20%	HCA Weed Killer Concentrate	General Chemical Division Allied Chemical Corp.
Ethylene dipyridilium dibromide	4 Lb/Gal	FB2	Chipman Chemical Company, Inc.
AT (Amitrol or Amino Triazole)	50%	Weedazol	Amchem Products, Inc.
2,4-D Amine (1957 only)	4 Lb/Gal	2,4-Dow Weed Killer	Dow Chemical Company
2,4-D Amine (1958-59)	4 Lb/Gal	2,4-D Weed Killer	Monsanto Chemical Company
2,4,5-T Amine (1957 only)	4 Lb/Gal	Dow 2,4,5-T Amine Weed Killer	Dow Chemical Company
2,4,5-T Amine (1957 only)	4 Lb/Gal	Dow 2,4,5-T Amine Weed Killer	Dow Chemical Company
2,4,5-T Amine (1958-59)	4 Lb/Gal	Veon 245	Dow Chemical Company
2(2,4,5-T) P	4 Lb/Gal	Kuron	Dow Chemical Company
PBA-Polybenzoic Acid (oil soluble)	2 Lb/Gal	ACP Benzac 103-A	Amchem Products, Inc.
PBA-Polybenzoic Acid (oil soluble)	2 Lb/Gal	ACP M94A	Amchem Products, Inc.
PBA-Polybenzoic Acid (water soluble)	4 Lb/Gal	ACP-M-354	Amchem Products, Inc.
Erbon	4 Lb/Gal	Baron	Dow Chemical Company
Diuron	80	Karmex	E. I. DuPont De Nemours & Company
Simazin	50	Simazine	Geigy Agricultural Chemicals
Atrazine	50%	Atrazine	Geigy Agricultural Chemicals
Monuron-TCA	3 Lb/Gal	Urox	General Chemical Division Allied Chemical Corporation
Fenuron-TCA	3 Lb/Gal	Urab	General Chemical Division Allied Chemical Corporation
Sodium Chlorate	2 Lb/Gal	Chlorax Liquid	Chipman Chemical Company, Inc.
Sodium Metaborate	1.67 Lb/Gal		
Sodium Chlorate	58	Atlacide-2,4-D	Chipman Chemical Company, Inc.
2,4-D	.06		
Sodium Chlorate	40%	Chlorea	Chipman Chemical Company, Inc.
Sodium Metaborate	57		
Monuron (Telvar W-80%)	1		
"RHB"			
Sodium TCA	14.24%	RHB TCA-Chlorate (Special D)	R. H. Bogle Company
Sodium Chlorate	28.49		
Calcium Chloride	17.09	Weed Killer	
Borate Compounds	94	Ureabor	U. S. Borax and Chemical Corp.
Monuron	4		
Agronyl Weed Killing Oil	100%	Agronyl - R	Socony Mobil Oil Company, Inc.
Conoco Weed Killing Oil	100%	Conoco Weed Spray Oil	Continental Oil Company
Herb NP-AT			
Oil	21.4	Herbicidol	
Cresols	1.8	NP-ATA	Reade Manufacturing Company
Xylenols	1.2		
Phenols	0.5%		
Sodium TCA	7.0%		
2,4-D	1.1%		
Amizol (ATA)	.7%		
Surfactants	12.0%		
Active Ingredients	45.7%		
Inert Ingredients	54.3%		
Monsanto 9303	Coded	Monsanto 9303	Monsanto Chemical Company
Monsanto 10847	Coded	Monsanto 10847	Monsanto Chemical Company
Monsanto 13842	Coded	Monsanto 13842	Monsanto Chemical Company
Sodium 2,3,6-Trichloro-phenylacetate (Fenac)	1 1/2 Lb/Gal	ACP M673A	Amchem Products, Inc.
Dalapon, Ethyl Ester	2 Lb/Gal	ACP M847	Amchem Products, Inc.

Fig. 2A—August 13, 1957.

Fig. 2B—October 16, 1958.

Fig. 2C—September 10, 1959.

Figs. 2A, 2B (opposite page), and 2C (above)—Dalapon (10 lb/acre); 2, 4–D–Amine (2 lb/acre) was applied twice per year; and diuron (10 lb/acre) was applied with the first spray application each year. Treatment No. 5 at Charlotte.

RESULTS

Those mixtures containing a residual-type herbicide, and most of those having growth-regulating type of herbicides gradually increased the degree of weed control through the three-year study. In some cases weed control was sufficiently good that it was not necessary to apply the full rate of the chemical in the second and third year. Those having only contact herbicidal effects usually gave only temporary control, with rather quick regrowth of perennial plants.

Each treatment will be discussed briefly. In some cases it will be desirable to discuss several treatments as a group. Reference to various treatments will be given as to location. The letters "CH" will be used for Charlotte and "HS" for Holly Springs. Where no location is given, the treatment number is the same at both locations. Treatment is abbreviated as Tr., and the number refers to that given in the left column of Tables 1 and 2.

Dalapon applied twice at the rate of 10 lb per acre (Tr. 1) gave better grass control than broad-leaved control. The repeated application of dalapon for 3 years gave better control of the woody plants than expected. The average of all ratings at both locations in 1957 was 4.5; 1958 was 5.6; and 1959 was 6.6.

Dalapon (40 lb/acre) and 2,4–D (8 lb/acre) applied once (Tr. 2) quickly kills the tops of plants, but does not favor translocation of the herbicide to below-ground parts. The average of ratings of both locations in 1957 was 5.1; 1958, 5.4; and 1959, 6.6.

Fig. 3A—August 13, 1957.

Fig. 3B—October 16, 1958.

Fig. 3C—September 10, 1959.

Figs. 3A, 3B (opposite page), and 3C (above)—Dalapon (10 lb/acre); 2, 4–D–Amine (2 lb/acre) was applied twice per year; and simazin (10 lb/acre) was applied with the first spray application each year. Treatment No. 6 at Charlotte.

Dalapon (20 lb/acre) and 2,4–D (4 lb/acre) applied twice (Tr. 3) gave good grass and broad-leaved weed control at both locations. This was the same amount of chemical as applied in Tr. 2 above, except that the chemical was divided into 2 applications per season. The average ratings of both locations for 1957 was 5.9; 1958, 7.5; and 1959, 7.8.

Dalapon (10 lb/acre) and 2,4–D (2 lb/acre) applied twice (Tr. 4) gave good broad-leaved and grass control at both locations. The rate of chemical application per season is one-half that of Tr. 2 and 3. Weed control was better than with Tr. 2 and only slightly inferior to Tr. 3. The average of ratings in 1957 was 5.5; 1958, 6.6; and 1959, 7.4.

The addition of diuron (10 lb/acre) (Tr. 5), or simazin (10 lb/acre) (Tr. 6) to dalapon and 2,4–D (Tr. 4) showed an increase in weed control at both locations. The dalapon, 2,4–D, diuron treatment (Tr. 5) (Fig. 2A, 2B and 2C) gave average weed control ratings in 1957 of 5.2; 1958, 8.7; and 1959, 9.2. The dalapon, 2,4–D, simazin treatment (Tr. 6) (Figs. 3A, 3B and 3C) gave weed-control ratings in 1957 of 5.3; 1958, 8.0; and in 1959, 9.0. It is possible that the single application of 10 lb of diuron or simazin would be better divided into two 5-lb applications along with the two applications of dalapon and 2,4–D. Additional research is needed to establish this point.

Dalapon (10 lb/acre) and diuron (10 lb/acre) (Fig. 4A, 4B and 4C) (Tr. 10) applied twice per year gave excellent grass and broad-leaved control at both locations.

Fig. 4A—August 13, 1957.

Fig. 4B—October 16, 1958.

Fig. 4C—September 10, 1959.

Figs. 4A, 4B (opposite page), and 4C (above)—Dalapon (10 lb/acre) was applied twice each year with diuron (10 lb/acre) applied with the first spray application each year. Treatment No. 10, Charlotte.

It is possible that the diuron would best be divided into two 5-lb treatments as discussed above.

Dalapon (10 lb/acre) mixed with 2,4,5-T (Tr. 7) or with 2(2,4,5-T)P (Tr. 8) or with PBA (Tr. 9) gave no increase in weed control beyond that obtained with equivalent rates of 2,4-D.

Amino triazole in combination with PBA, PCP, 2,4-D and TCI in 1957 and 1958 (Table 1, Tr. 11, 12, 13; Table 2, Tr. 11, 12) gave effective control of woody plants but little control of grasses. There appeared to be little or no advantage in combining amino triazole with PBA or 2,4-D (Table 1, Tr. 11; Table 2, Tr. 11, 12) since all three of these chemicals controlled the broad-leaved weeds but not the grasses. Amino triazole combined with PCP in 1958 and 1959 (Tr. 11) gave an average weed-control rating in 1959 of 5.6.

Amino triazole combined with simazin (Table 1, Tr. 12) gave excellent weed control, with an average weed-control rating in 1959 of 9.2. It is possible that a part of the success of this treatment can be attributed to the use of PBA in 1957. Amino triazole combined with TCA and diuron (Table 2, Tr. 12) used in 1958 and 1959 also gave excellent control of both grasses and woody plants, with a weed control rating in 1959 of 9.3.

Amino triazole (5 lb/acre) and dalapon (10 lb/acre) applied twice each season (Table 1, Tr. 14) gave average weed-control ratings in 1957 of 7.4; in 1958, 6.8; and in 1959, 7.8.

Fig. 5A—August 13, 1957.

Fig. 5B—October 16, 1958.

Fig. 5C—September 10, 1959.

Figs. 5A, 5B (opposite page) and 5C (above)—Oil (100 gal/acre) plus diuron (10 lb/acre) applied once each season. Treatment No. 18 at Charlotte.

The weed-killing oils give a contact effect that quickly eliminates all top growth hit with the oil. Regrowth of perennial weeds is usually quick, therefore giving rather low weed-control ratings at the end of the season (Table 1, Tr. 15, 16; Table 2, Tr. 13, 14). Thus the average of ratings for all 3 years for both oils averaged 4.4, with ratings for 1959 averaging 5.1.

The addition of simazin (10 lb/acre) or diuron (10 lb/acre) to the oil (Table 1, Tr. 17, 18) (Figs. 5A, 5B and 5C) considerably increased the season-long weed control. The average rating for the two materials in 1957 was 5.7; 1958, 8.0; and in 1959, 8.2.

Oil plus HCA as two treatments per year (Table 1, Tr. 10; Table 2, Tr. 15) gave an average weed control rating in 1957 of 4.7; in 1958, 6.5; and in 1959, 8.4. The addition of simazin (10 lb/acre) to the above chemicals (Table 2, Tr. 16) resulted in weed-control ratings in 1957 of 3.8; in 1958, 7.0; and in 1959, 8.7.

Oil plus PBA (Table 1, Tr. 20; Table 2, Tr. 17) gave average weed-control ratings in 1957 of 5.7; 1958, 8.2; and in 1959, 8.9. At Holly Springs (Table 2) simazin was included in this mixture in 1957. There is no way of knowing how much the simazin contributed to the excellent success of this treatment. However, the average rating in 1959 at Holly Springs (simazin applied in 1957) was 9.5 compared to Charlotte without simazon with a rating of 8.4.

Oil plus monuron-TCA (Table 1, Tr. 21; Table 2, Tr. 18) gave excellent weed control from the first year with average ratings in 1957 of 8.2; 1958, 8.7; and in 1959,

9.2. The treatment at Holly Springs was of sufficient excellence in 1957 that only one-half rates of the monuron-TCA was applied in 1958 and 1959.

Fenuron-TCA (Table 1, Tr. 22; Table 2, Tr. 19) was slightly less efficient for weed control than the monuron-TCA discussed above. The average rating for both locations in 1957 was 7.6; 1958, 8.2; and 1959, 8.1. To keep this treatment comparable to the monuron-TCA treatment, the rate at Holly Springs was reduced to one-half in 1958 and 1959. This treatment was more hazardous to oak trees growing about 60 ft from the edge of the roadbed than other treatments. Apparently there were enough roots extending into the treated area for sufficient absorption to kill a few trees.

Sodium chlorate and sodium metaborate as "Chlorax Liquid" plus diuron (Table 1, Tr. 23, 24; Table 2, Tr. 20, 21) gave excellent weed control, with average ratings in 1957 of 6.0; in 1958, 9.0; and in 1959, 9.6. There appeared to be little or no difference between one single heavy application and split application.

Herb NP–AT (Table 1, Tr. 25; Table 2, Tr. 22) was applied only in 1958 and 1959. Excellent weed control was the result, with an average rating of 8.3 in 1958; and 8.7 in 1959.

Erbon (Table 1, Tr. 27; Table 2, Tr. 24) gave excellent weed control from the first year on. The average ratings for both locations in 1957 was 8.1; 1958, 8.5; and 1959, 9.4. Weed Control in 1957 at Holly Springs was sufficient to cut the rate of chemical treatment in half for 1958 and 1959.

Diuron alone (Table 1, Tr. 28; Table 2, Tr. 25) gave rather poor weed control the first year, but very excellent control in the second and third year. The average weed control ratings for 1957 was 5.5; 1958, 9.3; and 1959, 9.5. At Charlotte weed control was sufficient at the end of the 1958 season that the chemical rate was reduced to one-half in 1959.

Simazin alone (Table 1, Tr. 29; Table 2, Tr. 26) gave results similar to diuron. Control was rather poor the first year, with very excellent weed control thereafter. The average weed control ratings for 1957 was 4.6; 1958, 8.4 and 1959, 9.3. At Charlotte weed control was sufficient that the chemical rate was reduced to one-half in 1959.

Atrazine and FB–2 (Table 1, Tr. 26; Table 2, Tr. 23) gave an average weed-control rating of 7.4 in 1958 and 8.9 in 1959. Atrazine was applied alone at Charlotte (Table 1, Tr. 33) in 1958 and 1959. The average weed-control rating in 1958 was 5.7 and in 1959, 7.5. Atrazine has a greater foliage toxicity than simazin, but perhaps a slightly shorter period of toxicity than simazin. Additional research is needed to establish the advantages of each for weed control on roadbeds.

The granular materials used in this experiment gave good weed control the first year, and very excellent weed control thereafter. Three granular materials were used, namely, "Ureabor", "Chlorea", and "Atlacide–2,4–D" (Table 1, Tr. 30, 31, 32; Table 2, Tr. 27, 28 and 29). At Holly Springs weed control was sufficient to reduce the rate of application to one-half the original for all three in 1958 and 1959. At Charlotte the rate was reduced on the Ureabor and Chlorea plots in 1959.

The "RHB" mixture of TCA, sodium chlorate and calcium chloride was applied only in 1958 and 1959 at Charlotte (Table 2, Tr. 34). The average weed-control rating after the first year was 4.2 and at the end of the second season, 7.7.

SUMMARY

Many herbicides and combinations of herbicides gave effective grass and woody plant control, especially if application was continued for 2 or more seasons.

Fig. 6—A sprayer built by the Norfolk Southern Railway which will apply 33 gal of spray per acre at 12–15 mph with a minimum amount of spray drift.

The effectiveness of some materials, especially some residual materials such as simazin or diuron, may not be entirely apparent until the second or third year of use.

With a long growing season in the Southeast there is an advantage in two applications of herbicide per year for some herbicides. However, some treatments were equally satisfactory with but one treatment per year.

With most treatments, satisfactory results were obtained with relatively low gallonage equipment (33 gal/acre). Uniform distribution is more important than total gallonage; unless the nature of the treatment requires high gallonage. Spray equipment (Fig. 6) is available that will give low gallonage with uniform distribution, and a minimum amount of spray drift.

A weed-control program can be planned to get effective control of a weedy track in one or two years time. After this time, considerable saving in treatment costs appears possible.

Part 2—Chemical Control of Vegetation—1959 AAR Report

The 1959 season marks the ninth year of research into the problem of vegetation control on railroad rights-of-way under Assignment 11 of AREA Committee 1—Roadway and Ballast. Extensive efforts have been directed toward finding chemicals which would provide effective results at a more economical cost. The AAR staff has made field observations each year of system-wide treatments and cooperative test sections conducted between railroads and chemical companies. The results have been evaluated

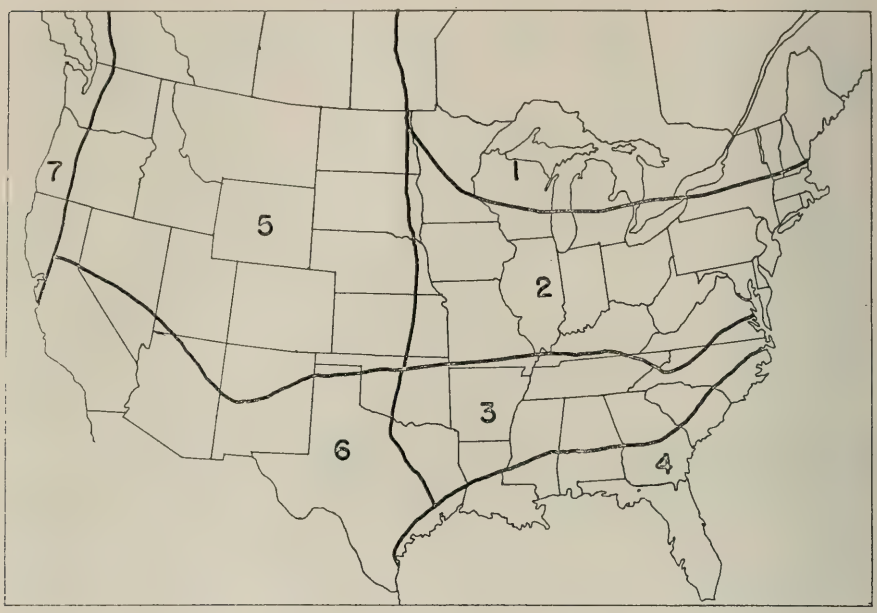

Fig. 1.

and presented as information in the AREA Proceedings, Vols. 53 through 60. To assist in these evaluations, the United States and Canada have been divided into seven general regions based on similar soil types, climatic conditions and vegetation (Fig. 1).

The AAR staff during 1959 inspected system-wide treatments on ten railroads for weed control and on five railroads for brush control in six of the seven regions. The results of these treatments are summarized in this report.

Test sections were followed on 16 railroads for weed control in all regions and on four railroads for brush control in four of the seven regions. In addition, an inspection was made of the test section at Iowa State College to determine the residual effects one year after the test had been terminated. Results of these test sections are summarized in Tables A and B and in Tables 1A through 9.

Observations this year indicate: (1) The need for a continuous vegetation control program on railroads. Neglect often results in serious problems that require additional expense in obtaining control. (2) Long-term system-wide programs continue to be more economical than those on a year-to-year basis. (3) Vegetation condition is rather a complex problem requiring personnel with specialized training and responsibility to analyze vegetation conditions and specify the best possible treatment for the particular problems involved and budget limitation.

Materials Used

Each year additional chemicals and chemical combinations become available for vegetation control purposes. At present there are more than 80 such materials. Combinations of these continue to be the most widely used for controlling weeds on main and branch lines in all regions. These combinations include chlorate-borate materials,

methoxone–chlorate–borate mixtures, chlorate–borate–substituted urea compounds, chlorate–borate–triazine mixtures, phenoxy–chlorate–borate–substituted urea compounds. phenoxy–chlorate–borate–triazine mixtures, chlorate–chloride, chlorate–TCA, dalapon–phenoxy compounds, dalapon-substituted urea-phenoxy compounds, aromatic oil-substituted urea mixtures, and aromatic oil-phenol-substituted urea-phenoxy mixtures. One application of these mixtures will usually provide good seasonal control when applied at the recommended rate in regions 1, 2, 5, 6 and 7. In extremely low rainfall areas it is possible to obtain two years control with mixtures containing soil-sterilant-type materials. Two applications per year may be required with mixtures containing only contact and/or translocated materials in higher rainfall areas, especially in regions 3 and 4 where the long growing season promotes vigorous plant growth.

Soil-sterilant-type materials were used primarily in yard areas, around bridges and trestles, communication poles, signal stands, buildings, road crossings, and as spot treatments for noxious weed control. Chemicals used for these purposes were sodium arsenite, Atlacide-2,4–D, Baron, Benzabor, Borascu, Borate slurry, Chlorea, Concentrated Borascu, monuron, Nalco H–174, Polybor Chlorate, Reade's M/W, Soil Sterilant, Simazine, Trysben, Ureabor and Urox. These materials have provided good results for one season in all regions when applied at recommended rates. In low rainfall areas it is possible to obtain two-years control.

Oils continue to be used primarily in the Midwest, South and Southeast. A single application provides fairly good control in the Midwest. Two and three treatments are necessary in the South and Southeast to maintain adequate control.

Cost

The cost data of various chemicals available during 1959 have been compiled and are included as information in Table 10. This table contains information on the chemical composition, recommended rate per acre, dilution, cost per pound or gallon f.o.b. plant and the cost per acre. The cost of any specific material is normally within this range, but it is subject to adjustment by commercial applicators as well as manufacturers.

Iowa State College Test

An inspection was made of the Iowa State College test on August 25 to determine the residual effects one year after the test had been terminated. A full description of these tests occurs in the Proceedings, Vol. 60, 1959, pages 715–722. One series of tests contained Urox and Simazine applied on December 22, 1957 in the form of pellets as well as solutions. Table A shows the results obtained during 1958 and 1959.

Table A—Results of Winter Applications of Simazine and Urox at Ames

Chemical	*Form*	*Rate Lb/A*[1]	*Percent Vegetation Control*	
			Sept. 19, 1958	*Aug. 25, 1959*
Simazine	Pellets	10	37	41
Simazine	Pellets	20	65	63
Simazine	Solution	10	64	12
Simazine	Solution	20	89	23
Simazine plus 100 lb chlorate	Solution	10	90	10
Simazine plus 100 lb chlorate	Solution	20	98	25
Urox	Pellets	20	69	20
Urox	Pellets	30	82	33

[1] Active ingredient.

During 1958 the solutions provided as good or better results than did the pellets. However, the 1959 results indicate that the Simazine pellets provided better residual effects than the solutions and Urox. Annual species were beginning to infest these areas.

Another test section inspected was the long-term repeated treatments established in 1953 involving three different spray plans. These spraying plans were: No. 1—Sprayed each year in early May (1953 to 1958 incl.). No. 2—Sprayed each year in early May (1953 to 1958 incl.) followed in 60 days by an oil treatment. No. 3—Sprayed on alternate years in early May (1953–1955–1957). Table B shows the results obtained during 1958 and 1959.

TABLE B—RESULTS WITH REPEATED TREATMENTS 1958 AND 1959

Chemical and Rate/Acre[1]	*Percent Control*					
	Spray Plan 1		*Spray Plan 2*		*Spray Plan 3*	
	1958	*1959*[3]	*1958*	*1958*[3]	*1958*	*1959*[3]
CMU-Chlorate, 10–80 lb	95	55	99	61	79	30
TCA-Chlorate, 40–80[2] lb	36	10	95	10	21	5
TCA, 40 lb	24	20	89	5	11	5
Oil (L-8764) 100 gal	39	10	76	10	25	5
TCA-Chlorate, 40–80 lb	35	5	97	5	35	3
Chlorate, 80 lb	56	50	97	20	12	5
CMU, 20 lb	99	90	99	85	95	60
CMU, 10 lb	86	50	98	60	64	--------

[1] Active ingredient.
[2] Plus 2 lb 2,4-D.
[3] Rating based on one replicate only.

Other Tests

Several tests were followed in all regions during 1959 (Tables 1A through 7). Some of these tests were established in 1956 for controlling vegetation on branch lines while others were established as long-term tests using granular materials in yards, tests for controlling specific problem species, and tests for determining the effectiveness of new materials.

One railroad in region 1 established a long-term test during May 1957 in yard areas using dry materials (Table 1A). Five materials were used on adjacent tracks at each location covering areas from 1775 to 7609 ft in length and 14 ft wide. Re-treatment was made in 1958 on four of these tests in each location. One test in each location was not re-treated during 1958. These areas were not re-treated in 1959. Results were fair to good in all tests except the area that received only one treatment in three years. Annual species had reinfested this area during the 1959 season.

Another railroad in region 1 established during 1959 a test for general vegetation control in yard areas using a solution of methoxone–chlorate–borate alone and in combination with triazine, substituted urea, trichlorophenylacetic acid and trichlorobenzoic acid. Detailed results of this test are reported in Table 1B.

A railroad in region 2 established an extensive test in a yard area using 21 dry or granular materials for the purpose of general vegetation control. These materials were applied on an active ingredient equivalent basis of 3–(p–chlorophenyl)–1, 1–dimethylurea and/or 2–cholor–4, 6–bis–(ethylamino)–s–triazine or equivalent cost basis. Practically all materials provided good control of annual species except in a few areas where annuals emerged under car drippings. Deep-rooted perennial species were quite resistant. Some areas were more heavily infested with perennial species than others, which may explain

Fig. 2—Test area in Region 2 treated during May 26, 1959, with a mixture of 75 gal Herbicidol–NP, 24 lb Kenapon and 6 lb Simazine per acre. Picture taken October 29, 1959.

the differences in the degree of control obtained among treatments and among replicates of the same treatment. Specific results are included in Table 2A.

A number of materials were applied in other test areas during 1958 in region 2 and observed this year. Results of these tests are included in Table 2B.

Another railroad in region 2 applied Herbicidal–NP plus Kenapon alone and in combination with trichlorobenzoic acid, trichlorophenylacetic acid, atrazine, simazin and diuron during May 1959. These treatments provided a good initial top kill, and the treatments, including soil-sterilant-type materials, maintained very good control throughout the season (Fig. 2). Specific results are included in Table 2C.

A number of materials, both granular and liquid, were applied on three test sections at different dates in region 2 for controlling bouncing bet, horsetail and bindweed. Some of the treatments show promise for controlling these species (Figs. 3 and 4). The early applications with the majority of materials used appear to provide better control of bouncing bet than late treatments. Results are summarized in Tables 2D and 2E.

Tests using dry granular materials as a pre-emergence treatment and solutions as a post-emergence treatment were applied in region 3 for general vegetation control. Specific results are included in Table 3A. Results of other materials tested in region 3 are included in Tables 3B and 3C. These include granular materials for controlling general vegetation in yard areas (Fig. 5), in addition to solutions of chlorate–borate–phenylacetic acid, dalapon–monuron, Garlon and granular experimental materials for controlling Johnson grass.

Dalapon–diuron mixtures were applied at two rates in region 4 for general vegetation control. The high rate appeared to provide fairly good control, but Bermuda grass sprigs and nut grass survived. Results are shown in Table 4.

One of the most extensive long-term test sections followed since 1956 covers 700 miles of branch line in region 5 (Table 5A). Three branch lines (266 miles) were in-

Fig. 3—Bouncing bet test area in Region 2. Picture taken at time of treatment on July 2, 1959.

Fig. 4—Bouncing bet control with Atlacide–2,4–D at 1740 lb per acre in Region 2. Treatment applied July 2, 1959. Picture taken September 18, 1959, in same area as Fig. 3.

Fig. 5—Control obtained with Soil Sterilant applied March 12, 1959 in Region 3. This yard area was treated between tracks only at the rate of 150 lb per acre. Area originally heavily infested with Bermuda grass. Picture taken October 21, 1959.

spected during 1959. The initial treatment was applied in June 1956 and re-treated in June 1957, June 1958 and June 1959. Two of these branch lines were not re-treated during 1958. Results were very good to excellent on all branch lines inspected (Figs. 6 and 7). Results of other materials tested in region 5 are included in Table 5B.

A railroad in region 6 applied mixtures of chlorate–borate-substituted urea at various rates during November 1957 for controlling vegetation on branch lines. An inspection was made this year to determine the residual effects. Only minor residual effects were observed with high rates of chlorate–borate, the medium rate of monuron maintaining the highest degree of control. Specific results for 1958 and 1959 are included in Table 6.

Test sections in region 7 include granular materials applied during December 1957 in a tie yard area as a firebreak (Fig. 8) and granular herbicides applied during December 1958 on a branch line for general vegetation control. Results are included in Table 7.

Following is a summary of results observed from various chemical treatments used by railroads for vegetation control on main lines, branch lines and in yard areas in six of the seven regions during 1959. The treatments summarized do not include all treatments used in the various regions, but only those inspected by the AAR staff. The names of the products used to designate the various materials are those presently accepted by the Weed Society of America. Rates are based on commercial formulation of these products.

WEED CONTROL

Region 1

A mixture of dalapon–silvex at the rates of 40 lb and 4 lb per acre, respectively, was used in yard areas during early July and inspected September 3, 1959. Species pres-

A

Fig. 6—Results of long-term test (4 years) in Region 5, Test 2. This area originally treated during June 1956 with 19 lb Radapon (dalapon) and 87 gal MCPA–Chlorax No. 2 per acre. Re-treated in June 1957 with MCPA–Chlorea 800 at 185 gal solution per acre. Not re-treated during 1958. Re-treated during June 1959 with MCPA–Chlorax and Simazine at 51 gal conc. and 6 lb per acre respectively. Picture taken September 2, 1959.

Fig. 7—Results of repeated treatments in long term test in Region 5 (Test 3). Originally treated during June 1956 with 9.6 lb Radapon (dalapon), 1.9 lb MCPA and 7.8 lb monuron (Telvar) per acre. Re-treated in 1957 with MCPA–Chlorea 800 at 195 gal solution per acre. Not treated during 1958. Treated again in June 1959 with MCPA–Chlorea 46 at the rate of 51 gal conc. per acre. Picture taken Sept. 2, 1959.

Fig. 8—Control 17 months after application with Nalco H–174S at 440 lb per acre around tie yards as a firebreak in Region 7. Treatment was made on December 12, 1957. Picture taken May 19, 1959.

ent were green foxtail, crabgrass, Mexican fireweed, prostrate spurge, sandbur, peppergrass, wild barley, marestail, quackgrass, and curled leaf dock. This treatment provided good control for the season, especially on broad-leaved species. The estimated control was 80 to 85 percent on September 3. Species that survived were sandbur, dock, quackgrass and a few plants of wild barley. In another yard treated with this mixture and infested with sandbur, prostrate spurge, small grain, crabgrass, Mexican fireweed, ticklegrass, milkweed, lovegrass, wild buckwheat, rush grass and quackgrass the control was 75 to 80 percent. Some regrowth occurred from small grain, prostrate spurge, ticklegrass, lovegrass and crabgrass.

A mixture containing 20 gal aromatic petroleum oil–PCP, 4 lb 2, 4–D and 8 lb monuron applied during early July was effective in maintaining good control for the season in yard areas. Species in these areas were quackgrass, Mexican fireweed, dandelion, Canada thistle, milkweed, yarrow and annual grasses. Control was approximately 90 percent on September 3.

Region 2

A combination of MCPA–CBM (chlorate–borate mixture) was used on main lines in this region at 50 gal concentrate per acre. This material when applied during early June provided a good initial kill and maintained control for the season. Species in this area were smooth brome grass, blue grass, smartweed, milkweed and wild rose. Smooth brome grass and blue grass were the predominant species that had survived on August 19.

A mixture contaniing 20 gal aromatic petroleum oil–PCP, 4 lb 2,4–D, and 8 lb monuron was applied during early July on branch and main lines in this region. Species present were smooth brome grass, wild barley, quackgrass, blue grass, Mexican fireweed, dandelion, pigweed and wild rose. Results were spotty when inspected on September 1. In some areas the percent control was 70 to 75 percent and 85 percent in others. Species that survived were smooth brome grass, wild rose and scattered dandelion plants.

Fig. 9—Results from two applications of aromatic oil at 100 gal per acre each in Region 3. First application was made June 17–18 and the second August 13, 1959. Picture taken September 8, 1959.

Region 3

A mixture of dalapon–monuron–2,4–D at rates of 20 lb, 10 lb and 4 lb per acre, respectively, was applied during late May on main lines in this region. Species present were Bermuda grass, Johnson grass, bouncing bet, crabgrass, bracken fern, horsenettle, dogbane, upright spurge, foxtail, broomsedge and wild onions. When inspected on October 22 the results were extremely spotty. There was evidence that the vegetation had been retarded with some reduction in stand. However, there was considerable regrowth of Bermuda grass, Johnson grass, bouncing bet and crabgrass. Bermuda grass was extremely heavy in some areas.

One yard in this region was treated with one main treatment of diuron–monuron at rates of 10 lb, 5 lb per acre, respectively, followed by three spot treatments later during the season using off-track equipment. Repeated spot treatments were necessary to insure adequate control on this heavily infested yard area. The initial application was made on March 17–20. The first spot treatment was applied on May 12–13 using diuron–monuron–dalapon–2, 4,5–T at rates of 10 lb 5 lb, 30 lb, 2 lb per acre, respectively, covering approximately one-third of the original area. The second spot treatment was made during early July with dalapon–monuron–amitrol at rates of 40 lb, 35 lb, 20 lb per acre, respectively, covering one-fifth of the original area. The third spot treatment was applied July 27 using dalapon–monuron–2,4,5–T at rates of 25 lb, 15 lb, 6 lb per acre, respectively, covering approximately one-tenth of the original area. Species in this area were Bermuda grass, crabgrass, prostrate spurge, aster and possibly others. Results were very good to excellent. Percent control on October 22 was estimated at 95 percent.

Two treatments of an aromatic oil at 100 gal per acre were applied in yard areas and on main lines of one railroad in this region (Fig. 9). The first application was made during mid-June and the second during mid-August. Species in the yard areas consisted of crabgrass, smartweed, ragweed, Johnson grass, pigweed, marestail, lambsquar-

ters, Cyprus spp., dock, ticklegrass, foxtail, small grain and Bermuda grass. Control three weeks after second application was very good (85 to 90 percent). Species that survived were Cyprus spp., dock and a few sprigs of Bermuda grass. Vegetation on the main line consisted of honeysuckle, bouncing bet, Johnson grass, alfalfa, foxtail, ragweed and other annuals. There was an excellent top kill on September 8. Some Johnson grass and bouncing bet were beginning to resprout.

CBMM (chlorate–borate–monuron mixture) was applied at the rate of 50 gal concentrate per acre (50 gal chlorate–borate mixture and 6 lb monuron) during mid-June in yard areas on one railroad in this region. Species present were crabgrass, lovegrass, peppergrass, pigweed, smartweed, marestail, ragweed, foxtail and knotweed. Results were very good when inspected September 9. The estimated percent control was 85 to 90 percent. A few crabgrass seedlings emerged along the edges of the rails during late summer.

In another area the CBMM was applied during mid-June on spur tracks at the rate of 50 gal concentrate chlorate–borate mixture and 6 lb monuron per acre. Vegetation consisted of crabgrass, upright spurge, blue grass, orchard grass, Bermuda grass, Dallis grass, three-seeded mercury, dandelion and Cyprus spp. Control in this area was 75 to 80 percent when inspected September 9. Species that survived were primarily perennials. In some damp areas where the monuron had leached beneath the plant root zone, annuals had emerged late during the season.

Another spur line was treated during mid-June with CBMM at the rate of 80 gal concentrate chlorate–borate mixture and 6 lb monuron per acre. Vegetation in this area consisted of trumpet vine, Bermuda grass, broom sedge, honeysuckle, Johnson grass, ragweed and foxtail. Results on this spur were poor to fair. There was evidence of considerable kill, however, Bermuda grass and trumpet vine were quite resistant and had heavily reinfested the area by September 9. Results were fair where these two species did not present a problem.

One railroad applied a spot treatment of CBM at the rate of 100 gal concentrate per acre on August 18 for controlling Johnson grass. Initial top kill was very good (95 to 100 percent), and the root kill appeared to be about 90 percent in some areas when inspected October 7. Johnson grass seedlings were emerging reinfesting approximately 10 to 25 percent of the area. Some of the Johnson grass had been mowed prior to treatment. In these areas the control was poor, with 80 percent regrowth.

Chlorate–chloride at the rate of 51 gal concentrate per acre was applied during mid-June on one railroad in this region. Species present were Bermuda grass, cheat grass, prostrate spurge, crabgrass, peppergrass, plantain, lambsquarters, primrose, smartweed, Johnson grass, wild lettuce, sweet clover, flea bane daisy, ragweed and nut grass. Initial results were very good when inspected July 9. Top kill was 85 to 95 percent. Control was fair to good on September 11. Bermuda grass had reinfested 50 percent of the area in some locations. Nut grass was also surviving. Annual species were beginning to reinfest some areas.

Region 5

One railroad treated branch lines with a combination of PCP–aromatic oil, fuel oil and 2,4–D at the rate of 10 gal mixture per mile 14 ft wide (equivalent to 6 gal mixture per acre). The application was made from a helicopter during late July and early August, operated at a speed of 30 mph. The capacity of the two spray tanks was approximately 30 gal each, capable of covering approximately 6 miles without refilling. Application was made during calm weather in which the wind velocity was less than 10 mph. Spray work when winds exceed 10 mph may cause some difficulty in controlling

the spray pattern. The PCP–aromatic oil mixture contains 44 percent pentachlorophenol, 19 percent aromatic petroleum and 37 percent inert ingredient. The mixture applied per mile contained 4 gal PCP–aromatic oil mixture, 1 gal 2,4–D Ester (6 lb acid per gal) and 5 gal fuel oil. Species present were Mexican fireweed, smooth brome grass, foxtail, gumweed, blue grass, slough grass, smartweed, and wild rose. Control was poor when inspected on October 1. There was evidence that Mexican fireweed, which was the predominant species, had been injured by the 2,4–D. Its growth had been retarded and considerable distortion was evident. Apparently, the fireweed had almost reached maturity when treated. There was some injury of smartweed. Brome grass was heavy in some areas and was not affected. Other species were sparse and resistant.

A mixture of 20 gal aromatic petroleum oil, 4 lb 2,4–D and 8 lb monuron was used quite extensively on main lines of one railroad in this region. Species present were blue grass, quackgrass, brome grass, slough grass, foxtail, Mexican fireweed, milkweed, wild rose, smartweed, ground cherry and buckbrush. Results were spotty to good when inspected August 31. In some areas the control was only 70 percent and in others 85 percent. Species that survived were quackgrass, brome grass, slough grass, milkweed, wild rose, ground cherry and smartweed.

CBM was applied at the rate of 51 gal concentrate per acre on main lines of one railroad during early May. Vegetation in this area consisted of cheat grass, blue grass, bunch grass, wild oats, salt grass, Canada rye, buckbrush, wild licorice, milkweed, wild rose, Mexican fireweed, wild four-o'clock, mullen, evening primrose, Russian thistle, wild mustard, wild lettuce, aster and sweet clover. Results were good when inspected August 20. Control was estimated to be approximately 80 percent. Species that survived were wild licorice, wild four-o'clock, bunch grass, milkweed, buckbrush and some Mexican fireweed.

Region 6

MCPA–CBMM at the rate of 50 gal concentrate MCPA–CBM (chlorate–borate mixture) and 8 lb monuron was applied during November 1958 with off-track equipment on one railroad. Species in this area were Johnson grass, Russian thistle, puncture vine and annual grasses. Control was estimated at 90 to 95 percent when inspected May 21, 1959.

One railroad applied borate slurry with an on-track specially equipped slurry car from the bridges at the rate of 5 lb per lin ft during June 1958. Species present were salt grass, rye grass, wild oats, alkali mallow, Mexican fireweed, Russian thistle and alkali lambsquarters. Control was very good to excellent when inspected in mid-May 1959.

The borate slurry was also used in yard areas with much success during 1959. One yard was treated with the slurry at the rate of approximately 4000 lb per acre during March 1959. Vegetation consisted of Bermuda grass, Johnson grass, horsenettle, nut grass and small grain. Results were very good when inspected June 20, 1959. Control was estimated to be 90 percent. In another yard, the rate used was 3600 lb per acre. Application was during March 1959. Vegetation present consisted of Bermuda grass, Johnson grass, pigweed, Russian thistle, peppergrass and annual grasses. Control was 75 to 80 percent on June 21, 1959. Some spots of Bermuda grass survived but it was chlorotic. Pigweed also survived and showed signs of chlorosis. Other species were controlled.

Region 7

One railroad in this region applied BMM (borate–monuron mixture) in granular form at the rate of 270 lb per acre on February 6, 1957, 4 ft each side of track along

Fig. 10—General vegetation control in Region 7 using 20 gal Nalco H–178D, 4 lb 2,4–D and 15 lb monuron (Telvar). Treatment was made during May 1959. Picture taken August 25, 1959.

the ballast toe line. Vegetation consisted of California poppy, yellow star thistle, mustard, wild oats, perennial rye grass, Hordeum spp. and annual grasses. Control 27 months after application when inspected May 19 was 80 percent. Annual grasses and California poppy were beginning to encroach into the treated area.

Another railroad applied MCPA–CBMM at the rate of 50 gal concentrate MCPA–CBM and 8 lb monuron per acre on a 5-ft width on each side of the ballast during October 1958. Species present were yellow star thistle, salt grass, perennial rye grass, wild mustard, mullen, dock and annual grasses. Control was very good in the areas inspected on May 19.

A mixture of 20 gal aromatic petroleum oil–PCP, 4 lb 2,4–D and 15 lb monuron was applied on main and branch lines of one railroad during May (Fig. 10). Species consisted of bracken fern, orchard grass, blue grass, horsetail, Canadian thistle, and rye grass. A number of areas were inspected, the results of which were good to very good. Estimated percent control during late August was 80 to 95 percent. Bracken fern was the predominant species that survived. Other species that survived were horsetail, dandelion, Canada thistle and plantain.

BRUSH CONTROL

Low-volatile ester and amine formulations of 2,4–D—2,4,5–T continue to be used extensively for controlling brush in all regions, with AMS (ammonium sulfamate) being substituted for these materials in areas adjacent to crops or in states where the use of these compounds are restricted.

An extensive test program was initiated on four railroads this year for the purpose of determining better methods for controlling brush, using granular or pelletized materials, dormant basal sprays and cane broadcast or dormant stem spraying. These tests are located in four of the seven regions, the results of which are included in Tables 8 and 9 (Figs. 11, 12 and 13). Various methods of application were employed in applying the granular or pelletized materials. These were air gun, cyclone seeder, hand broadcast, tablespoon (basal for each stem) and aerial. The results obtained from the tablespoon method were outstanding, but considerable time is involved in such a method of application in comparison to broadcast foliage application. (Fig. 14). The air-gun method appears to be quite promising in applying dry materials (Fig. 15). This type of application is rapid, requires few personnel, does not require spray train, provides good distribution, and is easy to calibrate.

One railroad in region 2 demonstrated the use of a helicopter in applying dry materials on the roadbed area as well as under the pole line for brush control (Fig. 16). The brush test is now under evaluation, and its effectiveness will be determined late next spring.

There is a need for extending the length of the spraying season on brush. Based on information concerning cane broadcast or dormant stem treatment obtained from a leading college conducting research on brush control, a cane broadcast or dormant stem spray of oil soluble 2,4,5–T (Technical 6 lb per gal) was applied on one railroad during March, using on-track equipment (Table 8 and Fig. 17). Results justify further evaluations of such a treatment. Additional tests were applied during November and December 1959. Results will be reported in 1960.

The use of dry materials is primarily in the experimental stage. It is expected that these will have a definite place in a brush control program. Results (based on limited observation) indicate that dry materials containing fenuron and TBA (trichlorobenzoic acid) seem to be effective in controlling lateral root-sprouting species such as sumac, locust, sassafras and persimmon. These species are normally quite resistant to foliage-type applications and further observations seem to be justified. Soil types appear to influence the results obtained from the use of root absorbed materials. These materials are more effective and quicker reacting on sandy soil than on clay soil. This may be explained by the fact that a higher concentration of chemical is carried into the root zone more readily in sandy soils. Method of application is one of the problems encountered in the use of these materials. Another problem is the danger of injurying trees adjacent to the right-of-way. Caution should be taken in applying root-absorbed chemicals in areas where danger of injury may result from such an application.

Following is a summary of the results observed in 1959 of brush treatments on railroads, applied during 1957, 1958 and 1959.

Region 3

One railroad sprayed AMS at the rate of 25–35 gal per acre during September 1958 in this region. Species present were sweet gum, elderberry, sassafras, persimmon, boxelder, willow, red oak, red maple, wild cherry, dogwood pine and trumpet vine. There was evidence of a very good top kill when inspected June 10, 1959. Considerable resprouting occurred on all species, particularly sweet gum, elderberry, sassafras, persimmon, red oak and red maple.

In another area of region 3, 2,4–D—2,4,5–T was applied as a foliage spray, at the rate of 2–3 gal concentrate per acre during September 1958. Species consisted of sweet gum, elderberry, sumac, locust, elm, ash, pine, dogwood, red oak, mulberry, wild plum,

(Text continued on page 756)

Fig. 11—Brush control test area prior to treatment with granular or pelletized materials. Picture taken June 16, 1959.

Fig. 12—Same area as Fig. 11. Brush-control test four months after application of granular or pelletized materials. Application was made June 25, 1959. Test plot left side of track treated with Benzabor at 200 lb per acre. Test plot right side of track treated with Dybar 80 lb per acre. Picture taken October 6, 1959.

Fig. 13—Results of dormant basal treatment for controlling brush in Region 4 using Nalco H–175D in diesel oil (1:9 dil). Treatment was made Feb. 9, 1959 at the rate of 70 gal solution per acre. Picture taken July 21, 1959.

Fig. 14—Results in Region 3 of Dybar applied Feb. 10, 1959 using tablespoon method of application. Rate used was 2 tablespoons per stem at base of plant (equivalent to 64 lb per acre). Picture taken July 22, 1959.

Fig. 15—Air gun used to apply dry granular and pelletized materials on test areas in Region 2.

Fig. 16—Helicopter applying dry pelletized material in demonstration of its use in Region 2.

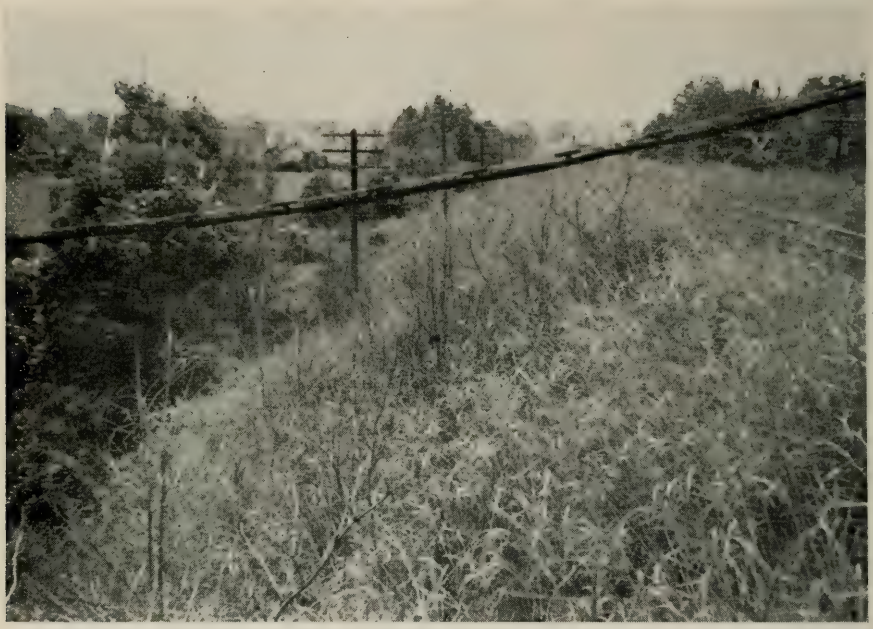

Fig. 17—Results of brush control test using a dormant cane broadcast or dormant stem application of oil soluable Technical T (6 lb acid equiv. 2,4,5–T per gal) in diesel oil. Application was made March 20, 1959 with on-track equipment. Rate applied was 9.5 lb 2,4,5–T and 144 gal diesel oil per acre. Picture taken June 11, 1959.

willow oak, and sycamore. Results on June 10, 1959 indicated a good initial top kill of all species except ash and pine which were resistant. Following species were intermediately susceptible with some resproutings, sumac, elderberry, elm, locust, oak, dogwood, willow oak, sycamore, wild plum and willow.

Results of brush-control chemicals applied during June 1957, using off-track equipment, were observed in this region. Two formualtions were used: one contained 2 lb per gal, 2,4–D and 2 lb per gal 2,4,5–T; and the other 1⅓ lb per gal 2,4–D and ⅔ lb per gal 2,4,5–T. Both formulations were applied in an oil-water emulsion using 10 gal oil per 100 gal solution and applied at approximately 2–3 gal concentrate per acre as a foliage spray. Vegetation consisted of ash, sumac, sassafras, elm, sycamore, wild plum, oak, maple, sweet gum, locust, persimmon, mulberry, boxelder, walnut and honeysuckle. The initial kill was very good 3 months following application. Control was also very good 15 months after treatment, with only 10 to 15 percent regrowth of elm and sumac. Results on September 8, 1959, 27 months after application, were fair. Estimated percent resprouting and regrowth was 25 to 30 percent. Predominant species that resprouted were sumac, sassafras, boxelder, locust and persimmon. These species were 5 to 7 ft tall except locust which was approximately 10 to 12 ft tall. Ash was resistant. No differences were noted in the response of the brush to the two different formulations.

A foliage spot treatment of 2,4–D—2,4,5–T at the rate of 2–3 gal concentrate per acre was applied on one railroad during July 1958. Species consisted of sumac, honey locust, elm, sassafras, maple, ash, persimmon, wild plum, pine and poplar. Results on

September 9, 1959, indicated that there was a very good top kill of all species. It was estimated that the total resprouting or regrowth was 30 percent. Species that resprouted were sassafras, sumac, elm and maple. Ash and persimmon appeared to have been resistant. Pine was intermediately susceptible to resistant.

This railroad also applied a spot treatment, at a different location, of this mixture during mid-July 1959. Species present were sumac, honey locust, elm, sassafras, pine, catalpa, wild plum, hickory, red bud, cedar, oak, maple, ash, poplar and persimmon. Initial top kill of the 1959 treatment appeared to be very good to excellent on September 9. Complete results cannot be determined until next year. A close examination revealed that the stems of locust, hickory, oak and red bud were not dead. The red bud leaves were green, but the leaves of other species had been burned. Cedar and pine were intermediately susceptible.

Region 7

One railroad used a considerable amount of 2,4,5–T at 1.5 gal per acre in an oil-water emulsion (1–4–100 mixture) during early June 1959, as a foliage spray. AMS was substituted at the rate of 34 gal per acre in areas adjacent to crops. Species consisted of alder, vine maple, salmon berry, Himalaya blackberry, evergreen blackberry, willow and wild rose. Results indicated a very good to excellent top kill when inspected on August 25–26, 1959.

Another railroad used 2,4–D—2,4,5–T (50:50 mixture) on foliage at the rates of 2 to 3 gal concentrate per acre during late July and early August 1959. Species consisted of vine maple, hazelnut, willow, Himalaya blackberry, evergreen blackberry, salmon berry, wild rose and alder. Results on August 27 indicated that there was approximately 80 percent top kill. Tops of all species had been burned except vine maple, which appeared to be quite resistant to this treatment. Complete results will not be evident until next year.

TABLE 1A—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 1

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Aug. 20, 1958	Sept. 29, 1958	Aug. 18, 1959	
Chlorea[1] Re-treated with Chlorea[2]	489 lb 340.4 lb	May 8–9, 1957 June 27, 1958	St. Paul, Minn. Station— Avg Max Temp: 1957—May—69.2°, June—76.8°, July—84.7°, Aug.—78.5°, Sept.—69.6°, Oct.—57.0°, Nov.—39.5°, Dec.—33.1°, 1958—Jan.—28.6°, Feb.—24.4°, Mar.—40.5°, Apr.—58.1°, May—73.7°, June—72.9°, July—79.1°, Aug.—80.6°, Sept.—73.2°, Oct.—63.4°, Nov.—45.3°, Dec.—24.7°. 1959—Jan.—20.3°, Feb.—27.1°, Mar.—43.4°, Apr.—59.1°, May—71.6°, June—80.0°, July—83.4°, Aug.—83.4°, Sept.—72.2°. Precipitation: 1957—May 3.91″, June—4.22″, July—6.28″, Aug.—5.01″, Sept.—1.99″, Oct.—1.50″, Nov.—1.42″, Dec.—0.21″. Annual Precipitation: 1957—28.31″. 1958—Jan.—0.25″, Feb.—0.06″, Mar.—0.36″, Apr.—2.68″, May—1.18″, June—2.52″, July—3.74″, Aug.—3.10″, Sept.—1.39″, Oct.—1.90″, Nov.—0.89″, Dec.—0.14″. Annual Precipitation: 1958—18.21″. 1959—Jan.—0.05″, Feb.—0.45″, Mar.—0.42″, Apr.—0.77″, May—5.69″, June—1.91″, July—2.96″, Aug.—6.93″, Sept.—2.94″.	Foxtail, smooth brome grass, Panicum spp., sandbur, prostrate spurge, Russian thistle, quackgrass, small grain, mallow, blue grass, pigweed, crabgrass, witchgrass and others.	90	95	60	1957 Results—Good kill Some regrowth of foxtail grass and few plants of prostrate spurge. 1958 Results—Some annuals came in during early spring prior to re-treatment. The 1958 treatment eliminated most species except Panicum spp. Very good control Sept. 19. 1959 Results—Area clean between rails. Annuals reinfested area between tracks. These were prostrate spurge, foxtail grass, pigweed, sandbur, Russian thistle and small grain. Panicum spp. survived.
Chlorea[2] Re-treated with Chlorea[2]	277.7 lb 340.4 lb	May 8–9, 1957 June 27, 1958	"	"	85	88	60	1957 Results—Good kill. Minor regrowth of foxtail grass, prostrate spurge and sandbur. 1958 Results—Some annual species reinfested area during early spring prior to re-treatment. The 1958 treatment provided good control. Panicum spp. was resistant to this treatment. 1959 Results—Between rails relatively free of vegetation. Area between tracks reinfested with annuals. These were prostrate spurge, foxtail grass, pigweed, sandbur, Russian thistle and small grain. Panicum spp. resistant.

TABLE 1A (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Aug. 20, 1958	Sept. 29, 1958	Aug. 18, 1959	
Ureabor[3]	435 lb	May 8 9, 1957	"	"	85	84	90	1957 Results—Good control. Some regrowth of foxtail grass, prostrate spurge, Russian thistle and Panicum spp. 1958 Results — Control was good at end of season. A few annual species such as prostrate spurge, sandbur and mallow were present during August and September. Panicum spp. was resistant but its growth appeared to be retarded and some plants showed signs of injury from the chemical. 1959 Results—Very good control. A few plants of prostrate spurge and Russian thistle present during last inspection.
Re-treated with Ureabor	435 lb	June 10–15, 1958						
Nalco H-174[4] Not re-treated	250 lb	May 9, 1957	"	"	70	70	25	1957 Results—Very good control during 1957. Few plants of Panicum spp. survived. 1958 Results—This treatment maintained good control until late summer at which time annuals began to reinfest the area. These annuals were prostrate spurge, green foxtail grass, sandbur, pigweed and mustard. The density of these annuals was sparse but their growth was rank. Panicum spp. survived in isolated bunches. 1959 Results—This area heavily infested with the following species: foxtail grass, Mexican fireweed, pigweed, prostrate spurge, Russian thistle, sandbur, sunflower, ragweed, peppergrass and small grain.

TABLE 1A (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Aug. 20, 1958	Sept. 29, 1958	Aug. 18, 1959	
Urox[5] Not re-treated	100 lb	May 16, 1957	"	"	60	85	70	1957 Results—Very good control. Soil practically sterile. 1958 Results—This treatment maintained good control until late summer after which annual species reinfested the area. These annuals were primarily prostrate spurge, foxtail grass, pigweed, Russian thistle and lovegrass. Panicum spp. was resistant to this treatment but only a few isolated bunches were present in this test area. The reason for a higher rating during Sept. 1958 is unexplainable unless some of the annuals had been disturbed, killed by a light frost or their root zone reached the chemical level in the soil. 1959 Results—Prostrate spurge and foxtail reinfesting this area.
Urox	100 lb	May 16, 1957	"	"	85	95	85	1957 Results—Very good control. Soil practically sterile. 1958 Results—This treatment maitained good control throughout the 1958 season. A few annuals such as prostrate spurge and pigweed were present during the August 1958 inspection but were not present six weeks later. A few plants Panicum spp. survived. 1959 Results—Maintained good control. Prostrate spurge and small grain infested this area.
Re-treated with Urox	100 lb	June 10, 1958						

TABLE 1A (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Aug. 20, 1958	Sept. 29, 1958	Aug. 18, 1959	
Urox	100 lb	May 16, 1957	"	"	95	95	90	1957 Results—Very good control. Soil practically sterile. 1958 Results—This treatment maintained very good control throughout the 1958 season. There were a few isolated plants of prostrate spurge that came in late during the summer. A few isolated clumps of Panicum spp. survived but its growth had been retarded and it showed signs of injury. 1959 Results—Very good control. A few plants of prostrate spurge and small grain were present during the last inspection.
Re-treated with Urox	75 lb	June 10, 1958						
Urox	100 lb	May 16, 1957	"	"	98	95	90	1957 Results—Very good control. Soil practically sterile. 1958 Results—This treatment maintained very good control during the 1958 season. There was no apparent difference in this treatment and the area retreated with 75 lb Urox. 1959 Results—Very good control. A few plants of prostrate spurge and small grain infested this area.
Re-treated with Urox	60 lb	June 10, 1958						
Nalco H-174 Not re-treated	250 lb	May 9, 1957	"	"	73	60	10	1957 Results—Very good control. Soil practically sterile. 1958 Results—This treatment maintained good control during the 1958 season until late summer. Annuals reinfesting this area were prostrate spurge and foxtail. Panicum spp. was resistant in this test. 1959 Results—Heavy regrowth with Mexican fireweed, Russian thistle, foxtail, prostrate spurge and Panicum spp.

TABLE 1A (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Aug. 20, 1958	Sept. 29, 1958	Aug. 18, 1959	
Urox Not re-treated	150 lb	May 16, 1957	"	"	80	75	65	1957 Results—Good control when inspected August 15, 1957. Some regrowth of foxtail and Panicum spp. 1958 Results—Maintained control during 1958 season. Annuals such as foxtail, prostrate spurge, crabgrass and Mexican fireweed infested this area during late summer. Panicum spp. was resistant. 1959 Results—This area was reinfested with prostrate spurge, Mexican fireweed, witchgrass and Panicum spp. when inspected in August 1959.
Urox Re-treated with Urox	150 lb 25 lb	May 16, 1957 June 10, 1958	"	"	75	75	80	1957 Results—Good control. Some regrowth of foxtail and Panicum spp. 1958 Results—Good control until late summer at which time annuals reinfested the area. Panicum spp. was resistant. 1959 Results—Good control. Some Mexican fireweed, prostrate spurge and witchgrass infested withis area. Panicum spp. was resistant.
Urox Re-treated with Urox	150 lb 50 lb	May 16, 1957 June 10, 1958	"	"	95	95	80	1957 Results—Good control. Some regrowth of foxtail and Panicum spp. 1958 Results—Maintained very good control. Some prostrate spurge and foxtail present during late summer. 1959 Results—Good control. Some prostrate spurge, Mexican fireweed and witchgrass present when inspected in September 1959. Panicum spp. was resistant.

TABLE 1A (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Aug. 20, 1958	Sept. 29, 1958	Aug. 18, 1959	
Urox	150 lb	May 16, 1957	"	"	95	95	85	1957 Results—Good control. Some regrowth of foxtail and Panicum spp. 1958 Results—Very good control with a few annuals present late in season. 1959 Results—Good control. Prostrate spurge, Mexican fireweed and witchgrass present during last inspection August 1959. Panicum spp. was resistant.
Re-treated with Urox	75 lb	June 10, 1958						
Urox	75 lb	June 10, 1958	"	"	30	40	20	1957 Results — Not treated. Heavy growth during 1957 season. 1958 Results—Treatment not sufficient to eliminate all vegetation during 1958. Annuals such as foxtail, crabgrass and Mexican fireweed heavily infested the area. 1959 Results—Heavily infested with prostrate spurge, Mexican fireweed and witchgrass when inspected during August 1959. Some Panicum spp. was present.
Not re-treated								
Chlorea[1]	625 lb	May 8-9, 1957	"	"	75	92	60	1957 Results—Good control. Some regrowth of prostrate spurge. Few plants of Panicum spp. survived. 1958 Results—Considerable regrowth during mid-summer. Chemical became progressively better throughout the season. Species present were quackgrass, Mexican fireweed, crabgrass and green foxtail. 1959 Results—Area reinfested with prostrate spurge, Mexican fireweed, Russian thistle and Panicum spp.
Re-treated with Chlorea[2]	340.4 lb	June 27, 1958						

TABLE 1A (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Aug. 20, 1958	Sept. 29, 1958	Aug. 18, 1959	
Chlorea[2]	432.6 lb	May 8–9, 1957	"	"	85	94	90	1957 Results—Good control. Few plants of Panicum spp. survived. 1958 Results—Some regrowth occurred during spring with annual species but the 1958 treatment eliminated these species. 1959 Results—Very good control. A few plants of prostrate spurge and Russian thistle were present during the August 1959 inspection.
Re-treated with Chlorea[2]	340.4 lb	June 27, 1958						
Ureabor	435 lb	May 9, 1957	"	"	92	90	90	1957 Results—Good control all species except a few plants of Panicum spp. which survived. 1958 Results—Maintained good control throughout the season. Few scattered plants of foxtail, Mexican fireweed and Russian thistle came in late during the season. 1959 Results—Very good control. A few plants of Russian thistle, Mexican fireweed and prostrate spurge were present when inspected during August 1959.
Re-treated with Ureabor	435 lb	June 10–15, 1958						

[1]Chlorea—Sodium chlorate 40%, sodium metaborate 57%, (monuron) 3-(p-chlorophenyl)-1,1-dimethylurea 1%.
[2]Chlorea—Sodium chlorate 40%, sodium metaborate 54%, (monuron) 3-(p-chlorophenyl)-1, 1-dimethylurea 2.4% (Technical).
[3]Ureabor—Disodium tetraborate pentahydrate 63.2%, disodium tetraborate decahydrate 30.8%, (monuron) 3-(p-chlorophenyl)-1, 1-dimethylurea 4%.
[4]Nalco H-174—Sodium tetraborate 83% (monuron) 3-(p-chlorophenyl)-1, 1-dimethylurea 8%, inert (surfactants) 9.0%.
[5]Urox—(monuron) 3-(p-chlorophenyl)-1, 1-dimethylurea and trichloroacetate 22%.

TABLE 1B—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 1

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Methoxone-Chlorax[1] plus Simazine[2] Telvar[3]	30 gal 3 lb 3 lb	June 25–26, 1959	Minneapolis Airport, Minnesota Station—Avg Max Temp: 1959—Jan.—19.5°, Feb.—26.5°, Mar.—43.1°, Apr.—57.4°, May—70.7°, June—80.3°, July—85.4°, Aug.—84.6°, Sept.—72.8°. Precipitation: Annual—1958—16.20″. Departure from avg (—8.51″). 1959—Jan.—0.11″, Feb.—0.61″, Mar.—0.59″, Apr.—0.64″, May—5.03″, June—4.07″, July—2.60″, Aug.—6.60″, Sept.—2.29″. Note: Precipitation—June 25, 1959—2.05″, June 26, 1959—0.32″ and June 27, 1959—0.30″.	Quackgrass (predominant grass), Mexican fireweed (predominant broad-leaved species). Other species — lambsquarters, marestail, peppergrass, ragweed, pigweed, mustard, lovegrass, smartweed, smooth brome grass, dandelion, prostrate spurge, wild buckwheat, aster, butter-and-eggs, Panicum spp., sandbur, slender rush, tickle-grass and small grain.	75	Yard area—width 14 ft, length 2,894 ft. (0.929 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Control 90 percent in all areas except 2 ft strip each side track under car drippings. In this 2 ft strip area control was about 40 percent. Species present at inspection were primarily Mexican fireweed and quackgrass. Other species were small grain, dock, dandelion, wild buckwheat and peppergrass.
Methoxone-Chlorax plus Simazine Telvar	30 gal 4 lb 4 lb	June 25–26, 1959	"	"	62	Yard area—width 14 ft, length 2,719.4 ft (0.875 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Difficulty encountered in application. Evidence of plugged nozzles. Control 75 percent in all areas except 2 ft strip each side under car drippings. Under car drippings the control was approximately 30 percent. Predominant species present during inspection were Mexican fireweed and quackgrass. Quackgrass was resistant but fireweed came in under the car drippings. A few plants had not been adequately covered with chemical. Other species that survived were smooth brome grass, foxtail, wild buckwheat, dock (top killed but resprouted), lovegrass, dandelion and prostrate spurge.

TABLE 1B (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Methoxone-Chlorax plus Simazine	30 gal 6 lb	June 25–26, 1959	"	"	72	Yard area—width 14 ft, length 2,546 ft (0.817 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Control 85 percent in all areas except 2 ft strip each side track under car drippings. Control under car drippings was 40 percent. Predominant species surviving during inspection were quackgrass and Mexican fireweed. Quackgrass appeared to be resistant and fireweed came in under the car drippings. Some dandelion plants were surviving.
Methoxone-Chlorax plus Simazine	30 gal 8 lb	June 25–26, 1959	"	"	62	Yard area—width 14 ft, length 2,373 ft (0.71 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Control approximately 80 percent in all areas except under car drippings. Under car drippings control was 20 percent. Predominant species at inspection was quackgrass (resistant), Mexican fireweed and prostrate spurge. Some lovegrass, aster and butter-and-eggs survived.
Methoxone-Chlorea 48 S[4]	30 gal	June 25–26, 1959	"	"	45	Yard area—width 14 ft, length 2,200 ft (0.707 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Difficulty encountered in application. Evidence of nozzles being plugged. Control 60 percent in all areas except under car drippings. Control under car drippings was approximately 10 percent. This area heavily infested with Mexican fireweed and prostrate spurge. Some heavy spots of quackgrass appeared to be resistant. Other species surviving were butter-and-eggs and marestail.

TABLE 1B (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Methoxone-Chlorea 46 S[5]	30 gal	June 25–26, 1959	"	"	65	Yard area—width 14 ft, length 2,027.6 ft (0.651 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Difficulty encountered in application. Evidence of plugged nozzles. Overall control approximately 65 percent. Primary infestation was under car drippings. Predominant species present during inspection were quackgrass (resistant), Mexican fireweed, prostrate spurge, Panicum spp. (resistant) and butter-and-eggs (resistant).
Methoxone-Chlorax[6]	50 gal	June 25–26, 1959	"	"	30	Yard area—width 14 ft, length 1,854 ft (0.594 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Overall control approximately 30 percent. Fair control of broad-leaved species. Grasses heavy. Predominant species was quackgrass which was resistant. Some Panicum spp., ticklegrass, prostrate spurge and Mexican fireweed present when inspected.
Methoxone-Chlorax plus Fenac[7]	50 gal 4 lb	June 25–26, 1959	"	"	25	Yard area—width 14 ft, length 1,682 ft (0.541 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Overall control approximately 25 percent. This plot was heavily infested with quackgrass and Mexican fireweed. Some of the fireweed was injured.
Methoxone-Chlorax plus Fenac	50 gal 6 lb	June 25–26, 1959	"	"	35	Yard area—width 14 ft, length 1,508 ft (0.485 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Overall control 35 percent. Good control broad-leaved species. This area heavily infested with quackgrass which was resistant. Some Panicum spp. (resistant) and prostrate spurge present when inspected.

TABLE 1B (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Methoxone-Chlorax[1] plus Fenac[7]	50 gal 8 lb	June 25–26, 1959	"	"	75	Yard area—width 14 ft, length 1,413 ft (0.453 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Control 90 percent except 2 ft each side rail under car drippings. Control under car drippings 40 percent. Species present during inspection were quackgrass (resistant), Mexican fireweed, prostrate spurge, tickle-grass and marestail.
Methoxone-Chlorea 48[8]	50 gal	June 25–26, 1959	"	"	85	Yard area—width 14 ft, length 2,696.7 ft (0.865 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Very good broad-leaved control. Quackgrass appears to be resistant.
Methoxone-Chlorax[1] plus Trysben[9]	50 gal 8 lb	June 25–26, 1959	"	"	70	Yard area—width 14 ft, length 1,061 ft (0.339 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Overall control approximately 70 percent. Good control broad-leaved species. Species present during inspection were Panicum spp. (resistant), slender rush and sandbur.
Methoxone-Chlorax[1] plus Trysben	50 gal 4 lb	June 25–26, 1959	"	"	70	Yard area—width 14 ft, length 1,323 ft (0.425 acre). Ballast—cinder, sand and soil. Inspected Sept. 3, 1959. Overall control approximately 70 percent. Good control broad-leaved species. Panicum spp. appeared to be resistant.

[1] Methoxone-Chlorax—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%.
[2] Simazine—2-chloro-4,6-bis-(ethylamino)-s-triazine 80%.
[3] Telvar—3-(p-chlorophenyl)-1-,1-dimethylurea 80%.
[4] Methoxone-Chlorea 48 S—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%, 3-(p-chlorophenyl)-1,1-dimethylurea 0.266 lb per gal concentrate, (Telvar applied at rate of 8 lb per acre).
[5] Methoxone-Chlorea 46 S—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%, 3-(p-chlorophenyl)-1,1-dimethylurea 0.20 lb per gal concentrate (Telvar applied at rate of 6 lb per acre).
[6] Methoxone-Chlorax—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.2%.
[7] Fenac—2,3,6-Trichlorophenylacetic acid 1.5 lb per gal active ingredient.
[8] Methoxone-Chlorea 48—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.2%, 3-(p-chlorophenyl)-1,1-dimethylurea 0.266 lb per gal concentrate.
[9] Trysben—Dimethylamine salt of trichlorobenzoic acid 24.8%, dimethylamine salt of other polychlorobenzoic acid 1.3%. Total active ingredient 26.1% (2 lb acid equivalent per gal).

Table 2A—Results of Chemical Treatments Applied on Test in Region 2

Type of Materials: Dry or Granular.
Location: Yard area.
Size of Test Plots: 8 ft wide between tracks, 545 ft long (0.1 acre) except following treatments: XPI-62 and XPI-63 (1/20 acre –13.9 ft wide, 157.2 ft long), Dybar and TBA Granules (1/30 acre—8 ft wide, 175 ft long) and Dybar-TBA Granules (1/30 acre—13.9 ft wide, 98 ft long).
Type of Vegetation: Predominant species—prickly lettuce, Canada thistle, quackgrass, crabgrass, dandelion, field bindweed.
Other species—squirrel tail barley, yellow nut grass, hemp, smartweed, red sorrel, smooth dock, curled leaf dock, lambsquarters, Mexican fireweed, wild four-o'clock, bladder campion, wild mustard, peppergrass, tumbling mustard, rough cinquefoil, black medic, prostrate spurge, whorled milkweed, Rugel's plantain, yarrow, common ragweed, bull thistle, marestail, daisy fleabane, perennial sowthistle, smooth brome grass, alfalfa, sunflower, blue grass, white sweet clover, yellow sweet clover, common milkweed, red clover, white clover, Queen Ann's lace, evening primrose, dogbane, green foxtail, chicory, witchgrass, goldenrod, dropseed, horsetail, butter-and-eggs, aster, rush grass, lovegrass, pigweed, horsenettle, wild buckwheat, prairie grass, big blue stem, Muhlenbergia spp. and cottonwood.
Weather Data: Chicago Air Port Station—Avg Max Temp: 1959—Jan. –28.2°, Feb.—33.5°, Mar.—45.2°, Apr.—58.2°, May—75.9°, June—82.6°, July—84.5°, Aug.—87.3°, Sept. –78.3°. Precipitation: Annual—1958—26.35″. Departure from Avg—(—6.37″). 1959—Jan.—1.89″, Feb.—2.39″, Mar.—3.91″, Apr.—4.00″, May—3.87″, June—5.94″, July—4.77″, Aug.—1.63″, Sept.—2.17″.
Date Applied: April 14, 1959.
Date Inspected: May 27, 1959, July 1, 1959 and September 29, 1959.
Ballast: Cinder and soil.

Treatment	*Rate Applied Per Acre*	*Percent Reduction Vegetation Sept. 29, 1959*[1]		*Remarks*
		Rep 1	*Rep 2*	
Dybar[2]	80 lb	0	.....	Rep 1 (only)—Original density only 10 percent with approximately 90 percent being broad-leaved species. Results—Approximately 50 percent reduction in density when inspected July 1, 85 percent being grasses. Area heavily infested with crabgrass during late summer resulting in higher density rating than originally. Grasses composed 90 percent of existing vegetation in Sept. Species that survived were crabgrass, milkweed, prostrate spurge and rush grass.
Dybar	120 lb	88	.....	Rep 1 (only)—Original density 80 percent with 90 percent being broad-leaved species. Results—Reduced stand approximately 68 percent by July 1. Species present during Sept. inspection were field bindweed (predominant species and resistant), crabgrass, prostrate spurge and dogbane. Broad-leaved species composed 70 percent vegetation.
Dybar	150 lb	93	.....	Rep 1 (only)—Original density 70 percent with 90 percent being broad-leaved species. Results—Approximately 72 percent reduction in stand on July 1. Broad-leaved species composed 95 percent of infestation. Control Sept. 29 was very good. Bindweed was resistant and composed 80 percent of existing vegetation. Some crabgrass and dropseed infested area during late summer.
Atrazine 4-G[3]	500 lb	40	.....	Rep 1 (only)—Original density 50 percent composed of about 50 percent grasses and 50 percent broad-leaved species. Results—Approximately 20 percent reduction in vegetation on July 1 and 40 percent Sept. 29. Species that survived were primarily deep rooted perennials, 90 percent of which was field bindweed. Other species were milkweed, dogbane, horsetail and dropseed.

TABLE 2A (Continued)

Treatment	Rate Applied Per Acre	Percent Reduction Vegetation Sept. 29, 1959[1]		Remarks
		Rep 1	Rep 2	
Simazine 4-G[4]	500 lb	42	.....	Rep 1 (only)—Original density 60 percent with 65 percent being grasses. Results—Density of vegetation had been reduced about 42 percent on July 1. Deep rooted broad-leaved species composed 80 percent of species that survived. Density on Sept. 29 was approximately same as in July. Broad-leaved species composed 86 percent of the surviving vegetation, 83 percent of which was field bindweed. Other species that survived were horsetail, milkweed, dandelion, dogbane, prickly lettuce, cinquefoil, quackgrass and rush grass.
XPI-62[5]	500 lb	78	.....	Rep 1 (only)—Original density 90 percent with infestation being primarily horsetail. Results—Density of vegetation had been reduced about 45 percent by July 1. Horsetail composed 98 percent of surviving vegetation which covered 45 percent of area. Density on Sept. 29 had been reduced 78 percent from original density rating. Horsetail composed 95 percent of surviving vegetation. Other species that survived were dock, wild four-o'clock and dogbane.
XPI-63[6]	500 lb	54	.....	Rep 1 (only)—Original density 98 percent with infestation being primarily horsetail. Results—Density of vegetation reduced approximately 28 percent by July 1. Species that survived consisted of 60 percent horsetail and 20 percent each grasses and broad-leaved species. Density on Sept. 29 had been reduced 54 percent from original density rating. Horsetail composed about 75 percent of infestation with remaining infestation being primarily deep rooted broad-leaved species. Other species that survived were quackgrass, field bindweed, Canada thistle, aster, prickly lettuce, milkweed, dandelion and cinquefoil.
Nalco H-174-S[7]	500 lb	94	.....	Rep 1 (only)—Original density 30 percent with approximately 50 percent being broad-leaved species and 50 percent grasses. Results—Very good control on July 1 and Sept. 29 with 94 percent reduction in stand, all grasses killed. Species that survived were a few plants of dogbane, dandelion and horsetail. Only 2 percent of area infested.
Nalco H-174[8]	250 lb	89	59	Rep 1—Original density 90 percent with 60 percent being broad-leaved species. Results—Reduced density of vegetation approximately 83 percent by July 1. Species that survived on July 1 consisted of 85 percent broad-leaved species and 15 percent grasses. These were aster, primrose, dogbane, dock, sweet clover, prickley lettuce, Canada thistle, cottonwood, quackgrass, and crabgrass (germinating). Density had been reduced about 89 percent by Sept. 29. Some broad-leaved species had been eliminated and crabgrass emerged composing 80 percent of surviving vegetation. Species that survived Sept. 29 were crabgrass, aster, dandelion, wild four-o'clock, dogbane, prostrate spurge and wild buckwheat. Note: East end light application not included in rating. Rep 2—Original density 98 percent with 70 percent being grasses. Results—Density of vegetation was reduced about 84 percent by July 1. Species that survived consisted of 90 percent broad-leaved species. These were prickley lettuce, smartweed, milkweed, dandelion, yellow sweet clover, whorled milkweed, and chicory. Grasses consisted of prairie grass and crabgrass (germinating). Density of vegetation increased to 40 percent by Sept. 29, 62 percent of which was grasses. Crabgrass infested area during late summer. Broad-leaved species that survived were milkweed, prickley lettuce, dogbane, smartweed and wild four-o'clock. Note: Three rails east end not treated and not included in rating.

TABLE 2A (Continued)

Treatment	Rate Applied Per Acre	Percent Reduction Vegetation Sept. 29, 1959[1]		Remarks
		Rep 1	Rep 2	
Reade MW-4[9]	500 lb	90	50	Rep 1—Original density 99 percent with approximately 50 percent being grasses and 50 percent broad-leaved species. Results—Density of vegetation reduced 70 percent by July 1. Seventy-five percent of surviving vegetation consisted of grasses. Total percent reduction of surviving vegetation by Sept. 29 was 90 percent. Species that survived were dandelion (predominant species), aster, wild buckwheat, dogbane, Canada thistle, milkweed, prickly lettuce, wild four-o'clock, prairie grass and foxtail grass. Note: Four rails east end not treated and not included in rating. Rep 2—Original density 60 percent with 70 percent being grasses. Results—Density of vegetation reduced 66 percent by July 1. Ninety percent of surviving vegetation consisted of broad-leaved species. Total percent reduction vegetation by Sept. 29 was 50 percent, 67 percent of which was broad-leaved species. These species were dandelion, aster, Canada thistle, prickley lettuce, dogbane and yarrow. Crabgrass infested area during late summer. Some Mulhenbergia spp. survived.
Reade MW-8[10]	250 lb	64	39	Rep 1—Original density 95 percent with 65 percent being broad-leaved species. Results—Density of vegetation reduced approximately 58 percent on July 1. Seventy-five percent of surviving vegetation consisted of broad-leaved species. Total reduction of vegetation by Sept. 29 was 64 percent. Species that survived consisted of 43 percent broad-leaved species and 57 percent grasses. These species were aster (predominant species), prickley lettuce (predominant species), daisy fleabane, dandelion, bindweed, milkweed, wild four-o'clock, crabgrass and prairie grass. Rep 2—Original density 98 percent with 75 percent being grasses. Results—Density of vegetation reduced approximately 39 percent on July 1 and Sept. 29. Species that survived Sept. 29 consisted of about 83 percent broad-leaved species. These were prickley lettuce (predominant species), Canada thistle, dandelion, aster, yarrow, wild four-o'clock, dogbane, daisy fleabane, chicory, and butter-and-eggs. Grasses that survived were quackgrass and prairie grass.
Benzabor[11]	250 lb	0	----------	Rep 1 (only)—Original density 65 percent with 70 percent being grasses. Results—Density of vegetation reduced approximately 30 percent on July 1. Grass species appeared resistant. Broad-leaved species susceptible. Density of vegetation had increased to about 75 percent by Sept. 29, 97 percent of which was grasses. Crabgrass composed 95 percent of grasses. Species that survived Sept. 29 were crabgrass, prairie grass, tickle grass, dropseed, dogbane (intermediately susceptible), Canada thistle (intermediately susceptible) and dock. (intermediately susceptible.)
Ureabor[12]	500 lb	70	82	Rep 1—Original density 65 percent with 70 percent being grasses. Results—Density of vegetation reduced approximately 70 percent on July 1 and Sept. 29. Species that survived consisted of 65 percent broad-leaved species and 35 percent grasses. These were prickley lettuce (predominant species), bindweed, quackgrass and prairie grass. Rep 2—Original density 80 percent with 70 percent being grasses. Results—Density of vegetation reduced approximately 93 percent on July 1 and 82 percent Sept. 29. Grasses controlled. Species that survived on Sept. 29 were dandelion, prickley lettuce and field bindweed.

TABLE 2A (Continued)

Treatment	Rate Applied Per Acre	Percent Reduction Vegetation Sept. 29, 1959[1]		Remarks
		Rep 1	Rep 2	
Chlorax S[13]	450 lb	60	97	Rep 1—Original density 98 percent with 65 percent being broad-leaved species. Results—Density of vegetation reduced approximately 90 percent on July 1. Species that survived consisted of 50 percent broad-leaved species and 50 percent grasses. These were prickley lettuce, field bindweed, Canada thistle, dogbane, milkweed, dandelion, prairie grass, cinquefoil and crabgrass (germinating). Area infested with crabgrass by Sept. 29. Density had increased to 40 percent, 60 percent of which was crabgrass. Other species that survived were prickley lettuce, aster, bindweed, prairie grass and tickle grass. Rep 2—Original density 80 percent with 70 percent being broad-leaved species. Results—Density of vegetation was reduced 94 percent by July 1 and 97 percent by Sept. 29. Species that survived consisted of a few plants dandelion, dogbane, cottonwood and prairie grass.
Chlorea Granular[14]	450 lb	75	94	Rep 1—Original density 98 percent with 60 percent being grasses. Results—Density of vegetation reduced approximately 94 percent by July 1. Species that survived on July 1 consisted of bladder campion, Canada thistle and chicory which composed 80 percent of existing vegetation. Praire grass and crabgrass (germinating) composed 20 percent of surviving vegetation. Density of vegetation had increased to 25 percent by Sept. 29, 80 percent of which was grasses. These were crabgrass (predominant species), foxtail grass, ticklegrass and Cyprus spp. Other species present were milkweed, dogbane, wild four-o'clock and prostrate spurge. Rep 2—Original density 85 percent with 70 percent being broad-leaved species. Density of vegetation reduced 94 percent on July 1 and Sept. 29. Species that survived on July 1 consisted of 75 percent broad-leaved species and 25 percent grasses. These were milkweed, dogbane, aster, cottonwood, prickley lettuce, dandelion, Cyprus spp. and crabgrass (germinating). Species that infested area on Sept. 29 consisted of 60 percent grasses and 40 percent broad-leaved species. These were crabgrass, quackgrass, dogbane and dandelion.
Soil Sterilant[15]	100 lb	53	85	Rep 1—Original desnity 85 percent with 50 percent being broad-leaved species and 50 percent grasses. Results—Density of vegetation reduced 41 percent by July 1. Species that survived were primarily broad-leaved species which composed 95 percent of vegetation. These were prickley lettuce, field bindweed, milkweed, goatsbeard, aster, dogbane, chicory and Canada thistle. Density of vegetation was reduced to 53 percent by Sept. 29. Species that survived were primarily broad-leaved species composing 90 percent of vegetation. These were prickley lettuce (predominant species), field bindweed, milkweed, dandelion, aster, dogbane and sunflower. Prairie grass only grass that survived. Rep 2—Original density 95 percent with 70 percent being broad-leaved species. Results—Density of vegetation reduced 89 percent by July 1. Species that survived were primarily broad-leaved species composing 90 percent of existing vegetation. These species were field bindweed, horsenettle, milkweed, wild four-o'clock, prickley lettuce, whorled milkweed and Canada thistle. Crabgrass was germinating. Density of vegetation had increased slightly by Sept. 29, but total reduction was 85 percent. Species that survived consisted of 67 percent grasses and 33 percent broad-leaved species. These were crabgrass (predominant species), foxtail grass, prairie grass, horsenettle, milkweed, dandelion, aster and dogbane.

TABLE 2A (Continued)

Treatment	*Rate Applied Per Acre*	*Percent Reduction Vegetation Sept. 29, 1959*[1]		*Remarks*
		Rep 1	*Rep 2*	
Urox 11[16]	300 lb	40	60	Rep 1—Original density 100 percent with 65 percent being grasses and 35 percent broad-leaved species. Results—Density of vegetation was reduced 30 percent by July 1 and 40 percent by Sept. 29. Species that survived were primarily broad-leaved species composing 70 percent of existing vegetation July 1 and 94 percent on Sept. 29. Resistant species Sept. 29 were prickley lettuce (80 percent of infestation), Canada thistle, field bindweed, dandelion, milkweed, butter-and-eggs, quackgrass and prairie grass. Rep 2—Original density 90 percent with 60 percent being grasses and 40 percent broad-leaved species. Results—Density of vegetation was reduced 50 percent by July 1 and 60 percent on Sept. 29. Species that survived July 1 consisted primarily of broad-leaved species composing 80 percent of vegetation. These were prickley lettuce, aster, dandelion, milkweed, sweet clover, Canada thistle, chicory, whorled milkweed and dogbane. Grasses were crabgrass (germinating) and foxtail. Resistant species Sept. 29 were prickley lettuce (predominant species), aster, dandelion, field bindweed, Canada thistle, wild four-o'clock, milkweed, dogbane, butter-and-eggs, crabgrass (predominant grass—infested area late summer), prostrate spurge and big bluestem.
Urox 22[17]	150 lb	39	39	Rep 1—Original density 90 percent with 70 percent being broad-leaved species and 30 percent grasses. Results—Density of vegetation reduced 66 percent by July 1 but had increased to 55 percent or a total reduction of 34 percent by Sept. 29. Species that survived were deep rooted broad-leaved species. These were prickley lettuce (predominant species), dandelion, aster, chicory and daisy fleabane. Some dogbane and field bindweed were present in July but were not noted in Sept. Rep 2—Original density, 90 percent with 70 percent being grasses and 30 percent broad-leaved species. Results—Density of vegetation reduced 65 percent by July 1 but increased tp 60 percent or 39 percent reduction by Sept. 29. Species that survived in July consisted primarily of broad-leaved species (90 percent of infestation) with some germinating of crabgrass. These were prickley lettuce (predominant species), Canada thistle, milkweed, dogbane, whorled milkweed, field bindweed, dandelion and Queen Ann's Lace. Considerable infestation of crabgrass occurred by Sept. 29. Resistant species in Sept. were prickley lettuce (predominant species), dandelion, chicory, Canada thistle, aster, goldenrod, dogbane, crabgrass (predominant grass) and foxtail.
TBA Granules[18]	20 lb		0	Rep 2 (only)—Original density 70 percent with 65 percent being grasses and 35 percent broad-leaved species. Results—Density of vegetation 75 percent when inspected July 1, 80 percent of which was grasses. Species were crabgrass, lovegrass, dropseed, field bindweed, milkweed, dogbane, prickley lettuce, butter-and-eggs, quackgrass and prostrate spurge. Area heavily infested with grasses during Sept. Density rating estimated to be 80 percent. Species that survived were crabgrass, dropseed, prickley lettuce, butter-and-eggs, dogbane, milkweed and bindweed.
TBA Granules	40 lb		0	Rep 2 (only)—Original density 70 percent with 65 percent being grasses and 35 percent broad-leaved species. Results—Density of vegetation reduced 20 percent by July 1 but was increased to 75 percent by Sept. 29. Resistant species Sept. 29 were primarily grasses (60 percent of infestation). These were quackgrass, dropseed, crabgrass and foxtail grass. Broad-leaved species that survived were carpet weed, prickley lettuce, butter-and-eggs, horsenettle, Canada thistle and pigweed.

TABLE 2A (Continued)

Treatment	Rate Applied Per Acre	Percent Reduction Vegetation Sept. 29, 1959[1]		Remarks
		Rep 1	Rep 2	
TBA-Granules	60 lb	----------	29	Rep 2 (only)—Original density 70 percent with 65 percent being grasses and 35 percent broad-leaved species. Results—Density of vegetation reduced 57 percent July 1 but infestation increased to 50 percent or a total reduction of only 29 percent by Sept. 29. Species that infested area Sept. 29 were carpet weed, dropseed, pigweed, lovegrass, upright spurge, Cyprus spp., horsetail, goldenrod, dogbane and milkweed.
Reade MW-4-F[19]	500 lb	----------	82	Rep 2 (only)—Original density 80 percent with 60 percent being grasses and 40 percent broad-leaved species. Results—Density of vegetation reduced 19 percent July 1 and 82 percent Sept. 29. Species that survived consisted of 70 percent grasses July 1 and 53 percent grasses Sept. 29. Resistant species Sept. were dropseed (predominant grass), prickley lettuce (predominant broad-eaved species), quackgrass (intermediately susceptible), dogbane and curled leaf dock.
Reade MW-4-A[20]	500 lb	----------	93	Rep 2 (only)—Original density 60 percent with 80 percent being grasses and 20 percent broad-leaved species. Results—Density of vegetation reduced 93 percent July 1 and Sept. 29. Species that survived July 1 consisted of horsetail (predominant species), dogbane, dandelion, Muhlenbergia spp., whorled milkweed, common milkweed and prickley lettuce. Resistant species Sept. 29 were horsetail (predominant species), dogbane and dandelion.
Dybar TBA-Granules	60 lb 20 lb	----------	8	Rep 2 (only)—Original density 98 percent with 90 percent being grasses (including horsetail)and 10 percent broad-leaved species. Results—No reduction of vegetation July 1 and only 8 percent Sept. 29. Horsetail composed 90 percent of infestation. Other species were Canada thistle, dogbane, milkweed, ticklegrass, foxtail and crabgrass.
Dybar TBA-Granules	40 lb 10 lb	----------	18	Rep 2 (only)—Original density 98 percent with 90 percent being grasses (including horsetail) and 10 percent broad-leaved species. Results—No reduction of vegetation July 1 and only 18 percent reduction Sept. 29. Horsetail composed 80 percent of infestation. Other species were crabgrass, ticklegrass, prickley lettuce, prostrate spurge, milkweed, butter-and-eggs, Canada thistle and dogbane.
TBA-Granules	80 lb	----------	18	Rep 2 (only)—Original density 98 percent with 90 percent being grasses (including horsetail) and 10 percent broad-leaved species. Results—No reduction of vegetation July 1 and only 18 percent Sept. 29. Horsetail composed 90 percent of infestation. Other species were foxtail, ticklegrass and milkweed (injured).
Dybar TBA-Granules	80 lb 30 lb	----------	18	Rep 2 (only)—Original density 98 percent with 90 percent being grasses (including horsetail) and 10 percent broad-leaved species. Results—No reduction of vegetation July 1 and only 18 percent reduction Sept. 29. Horsetail composed 85 percent of infestation. Other species were milkweed, Canada thistle, foxtail, ticklegrass and crabgrass.
Reade MW-4-S[21]	500 lb	----------	94	Rep 2 (only)—Original density 30 percent with 50 percent being grasses and 50 percent broad-leaved species. Results—Density of vegetation reduced 94 percent July 1 and Sept. 29. Only species that survived Sept. were dogbane and dandelion.

TABLE 2A (Continued)

Treatment	*Rate Applied Per Acre*	*Percent Reduction Vegetation Sept. 29, 1959*[1]		*Remarks*
		Rep 1	*Rep 2*	
Reade-MW-7[22]	500 lb	....	94	Rep 2 (only)—Original density 35 percent with 50 percent being grasses and 50 percent broad-leaved species. Results—Density of vegetation reduced 86 percent July 1 and 94 percent Sept. 29. Species that survived July 1 were prickley lettuce, dogbane, horsetail, Canada thistle, milkweed, cottonwood and prairie grass. Only species that were present Sept. 29 were prairie grass and milkweed.

[1]Percent Reduction Vegetation Sept. 29, 1959—Calculated from original density rating.
[2]Dybar—fenuron 3-phenyl-1,1- limethylurea 25% active ingredient.
[3]Atrazine 4-G—2-chloro-4-isopropylamino-6-ethylamino-s-triazine 4%.
[4]Simazine 4-G—2-chloro-4,6-bis-(ethylamino)-s-triazine 4%
[5]XPI-62—Experimental material.
[6]XPI-63—Experimental material.
[7]Nalco H-174-S—Experimental material. 2-chloro-4,6-bis-(ethylamino)-s-triazine (Simazine 50W)—10% or 5% (Technical), sodium tetraborate 83%, inert ingredient 7%.
[8]Nalco H-174—3-(p-chlorophenyl)-1,1-dimethylurea 8%, sodium tetraborate 83%, inert ingredient (surfactants) 9%.
[9]Reade MW-4—Sodium tetraborate decahydrate ($Na_2B_4O_7 \cdot 10H_2O$) 30.8%, sodium tetraborate pentahydrate ($Na_2B_4O_7 \cdot 5H_2O$) 63.2%, 3-(p-chlorophenyl)-1,1-dimethylurea 4%, inert ingredient 2%.
[10]Reade MW-8—Sodium tetraborate decahydrate ($Na_2B_4O_7 \cdot 10H_2O$) 87%, 3-(p-chlorophenyl)-1,1-dimethylurea 8%, inert ingredient 5%.
[11]Benzabor—Disodium tetraborate pentahydrate 54.5%, disodium tetraborate decahydrate 35.5%, trichlorobenzoic acid 8%.
[12]Ureabor—Disodium tetraborate pentahydrate 63.2%, disodium tetraborate decahydrate 30.8%, 3-(p-chlorophenyl)-1,1-dimethylurea 4%.
[13]Chlorax S—Sodium chlorate 40%, sodium metaborate 54%, 2-chloro-4,6-bis-(ethylamino)-s-triazine 2.4% (Technical).
[14]Chlorea Granular—Sodium chlorate 40%, sodium metaborate 54%, 3-(p-chlorophenyl)-1,1-dimethylurea 2.4% (Technical).
[15]Soil Sterilant—3-(p-chlorophenyl)-1,1-dimethylurea 21.33%, inert ingredient 78.67%.
[16]Urox 11—3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate 11%.
[17]Urox 22—3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate 22%.
[18]TBA-Granules—Trichlorobenzoic acid 25%.
[19]Reade MW-4-F—Experimental material containing trichlorophenylacetic acid.
[20]Reade MW-4-A—Experimental material containing atrazine.
[21]Reade MW-4-S—Experimental material containing simazin.
[22]Reade MW-7—Experimental material containing diuron and fenuron.

TABLE 2B—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 2

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*		*Remarks*
					Nov. 6, 1958	*Sept. 18, 1959*	
Ureabor[1]	435 lb	June 27, 1958	Chicago Air Port Station—Avg Max Temp: 1958—June—74.1°, July—81.5°, Aug.—83.2°, Sept.—75.5°, Oct.—67.4°, Nov.—50.8°, Dec.—29.5°. 1959—Jan.—28.2°, Feb.—33.5°, Mar.—45.2°, Apr.—58.2°, May—75.9°, June—82.6°, July—84.5°, Aug.—87.3°, Sept.—78.3°. Precipitation: 1958—June—6.43″, July—4.74″, Aug.—2.51″, Sept.—1.86″, Oct.—2.12″, Nov. 1.58″, Dec.—0.57″. Annual Precipitation—1958—26.35″. Departure from Avg: (—6.37″). 1959—Jan.—1.89″, Feb.—2.39″, Mar.—3.91″, Apr.—4.00″, May—3.87″, June—5.94″, July—4.77″, Aug.—1.63″, Sept.—2.17″.	Quackgrass, wild barley, Mexican fireweed, sweet clover, peppergrass, wild lettuce, dandelion, white clover, sunflower, blue grass, plantain, smartweed, aster, dropseed, mustard, curled leaf dock, bull thistle, goatsbeard, ragweed, prostrate spurge, wild four-o'clock, mint, timothy and black medic.	93	25	1958 Results—Some dandelion survived. Other species controlled. 1959 Results—Area reinfested during summer with wild lettuce, foxtail, Mexican fireweed, upright spurge, smartweed and ragweed.
DB-Granular[2]	978.75 lb	June 27, 1958	"	"	68	20	1958 Results—Eliminated broad-leaved species. Blue grass and quackgrass survived. 1959 Results—Area heavily infested with blue grass, quackgrass, foxtail and Mexican fireweed. Some sunflower, peppergrass and Panicum spp. present.
XPI-12A[3]	435 lb	June 27, 1958	"	"	90	65	1958 Results—Good control broad-leaved species. 1959 Results—Area reinfested with prostrate spurge, Mexican fireweed, foxtail, smartweed and Panicum spp.

TABLE 2B (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control		Remarks
					Nov. 6, 1958	Sept. 18, 1959	
XPI-12B[4]	435 lb	June 27, 1958	"	"	98	50	1958 Results—Excellent control. 1959 Results—Area infested with Mexican fireweed, prostrate spurge, foxtail, dock and Panicum spp.
Ureabor	870 lb	June 27, 1958	"	"	95	95	1958 Results—Excellent control. 1959 Results—Few plants wild lettuce and smartweed infested area.
XPI-12A	870 lb	June 27, 1958	"	"	95	98	1958 Results—Excellent control. 1959 Results—Excellent control. Few plants of wild lettuce in this area when inspected.
XPI-12B	870 lb	June 27, 1958	"	"	99	85	1958 Results—Excellent control. 1959 Results—Prostrate spurge and three-seeded Mercury infested area during late summer.
Urox[5]	125 lb	July 17, 1958	"	Blue grass, Mexican fireweed, crabgrass, prostrate spurge, smartweed and plantain.	95	90	1958 Results—Excellent control. 1959 Results—Very good control. Few plants prostrate spurge and crabgrass along edge of plot.
HCA[6] 2,4-D[7] Furnace Oil	3 gal 1 gal 96 gal	July 17, 1958	"	Blue grass, crabgrass, Mexican fireweed and smartweed.	75	20	1958 Results—Some blue grass survived. 1959 Results—Heavily infested with blue grass.
Urox	150 lb	July 17, 1958	"	Blue grass, crabgrass, Mexican fireweed, quackgrass, field bindweed and Canada thistle.	90	60	1958 Results—Good control. 1959 Results—Considerable regrowth of quackgrass and foxtail.

TABLE 2B (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control		Remarks
					Nov. 6, 1958	Sept. 29, 1959	
Arsenic Trioxide[8] plus Calcium chloride	1500 lb	June 10, 1958	"	Willow, goldenrod, mint, wild parsnip, burdock, yarrow, blue grass and aster.	45	0	1958 Results—Very little grass on this area. No effects on willow (predominant species). Controlled approximately 90 percent of all broad-leaved weeds (except willow) and 60 percent of grasses. 1959 Results—Heavy regrowth of willow 6 ft tall. Apparently crowded out other vegetation. Few plant sow thistle, milkweed and Canada thistle present. No grasses in plot.
Arsenic Trioxide plus Calcium chloride	1800 lb	June 10, 1958	"	Willow (predominant), goldenrod, mint, yarrow, Canada thistle, aster and blue grass.	70	0	1958 Results—Very little grass on this area originally. Eliminated approximately 95 percent broad-leaved weeds (except willow) and 98 percent grasses. Willow showed symptoms of injury. 1959 Results—Very heavy regrowth willow 6–8 ft tall. No other species noted in area.
Arsenic Trioxide plus Calcium chloride	2000 lb	June 10, 1958	"	Blue grass, Canada thistle, goldenrod, milkweed, sunflower, quackgrass and wild parsnip.	45	35	1958 Results—Controlled approximately 50 percent broad-leaved weeds and 40 percent grasses. Canada thistle and blue grass resistant. 1959 Results—Fair control grasses. Canada thistle and alfalfa predominant species and survived. Other species present were blue grass, goldenrod and sunflower.
Arsenic Trioxide plus Calcium chloride	2200 lb	June 10, 1958	"	"	55	45	1958 Results—Blue grass predominant species. Controlled approximately 80 percent broad-leaved weeds and 30 percent grasses. Canada thistle and blue grass resistant. Goldenrod intermediately susceptible. 1959 Results—Similar to 1958 results. Blue grass and Canada thistle predominant species. Some sunflower and goldenrod present in plot.

TABLE 2B (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*		*Remarks*
					Nov. 6, 1958	*Sept. 29, 1959*	
Arsenic Trioxide plus Calcium chloride	2500 lb	June 10, 1958	"	"	70	75	1958 Results—Controlled approximately 70 percent broad-leaved weeds and 70 percent grasses. Canada thistle resistant. Blue grass intermediately susceptible. 1959 Results—Control similar to 1958 results. Canada thistle predominant species but approximately 35–40 percent of it appeared dead. Vegetative form of horsetail had emerged but was killed. Other species in area were sunflower, alfalfa, goldenrod and blue grass.

[1]Ureabor—Disodium tetraborate pentahydrate 63.2%, disodium tetraborate decahydrate 30.8%, 3-(p-chlorophenyl)-1,1-dimethylurea 4%.
[2]DB Granular—Disodium tetraborate pentahydrate 55%, disodium tetraborate decahydrate 35.5%, 2,4-Dichlorophenoxyacetic acid equivalent 7.5%.
[3]XPI-12A—Experimental material.
[4]XPI-12B—Experimental material.
[5]Urox—3-(p-chlorophenyl)-1,1-dimethylurea and trichloroacetate 22%.
[6]HCA—Hexachloroacetone (3% by volume).
[7]2,4-D—2,4-Dichlorophenoxyacetic acid 4 lb acid equivalent per gal.
[8]Arsenic trioxide plus calcium chloride—As_2O_3 plus 2% calcium chloride.

TABLE 2C—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 2

Treatment	*Pate Applied Per Acre (Active Ingredient)*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Herbicidol-NP[1] Kenapon[2]	82.5 gal 24 lb	May 27, 1959	University of Chicago Station—Avg Max Temp: 1959—Jan.—26.8°, Feb.—33.3°, Mar.—43.9°, Apr.—55.4°, May—73.3°, June—77.9°, July—80.7°, Aug.—83.8°, Sept.—76.0°. Annual Precipitation: 1958—24.85″. Departure from Avg: (—7.39″). Precipitation: 1959—Jan.—2.05″, Feb.—2.38″, Mar.—4.09″, Apr.—4.43″, May—5.09″, June-2.91″, July—6.07″, Aug.—1.62″, Sept.—2.00″.	Predominant — Quackgrass and blue grass. Others—sweet clover, wild lettuce, cottonwood, Black-eyed Susan, wild parsnip, crabgrass, wild barley, Canada thistle, field bindweed, dandelion, orchard grass, horseweed, yarrow, sumac, common ragweed, lambsquarters, fleabane daisy, common milkweed, bouncing bet, butter-and-eggs, smartweed, dock and Cyprus spp.	20	Yard area—Size of area one acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Good initial top kill but heavily infested during late summer. Species surviving were Cyprus spp. (predominant), quackgrass, blue grass, and crabgrass.
Herbicidol-NP Kenapon Trysben[3]	82.5 gal 24 lb 6 lb	May 27, 1959	"	"	40	Yard area—Size of area one acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Good initial top kill. Reinfested during late summer primarily with crabgrass and Cyprus spp. Some blue grass, quackgrass, wild letuce and Canada thistle surviving.
Herbicidol-NP Kenapon Trysben	82.5 gal 24 lb 12 lb	May 27, 1959	"	"	70	Yard area—Size of area one acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Good control especially between track. Considerable growth between rails. Species surviving were blue grass (predominant), orchard grass, quackgrass, smartweed, dandelion, dock, Canada thistle and bindweed. Canada thistle and bindweed show signs of injury—some browning and dying of leaves. Some plants dead.
Herbicidol-NP Kenapon Fenac-S[4]	82.5 gal 24 lb 6 lb	May 27, 1959	"	"	75	Yard area—Size of area one acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Very good control between tracks. Considerable growth between rails. Surviving species were blue grass (predominant), quackgrass, wild lettuce, bindweed (severly injured—browning of leaves) and Canada thistle.

TABLE 2C (Continued)

Treatment	*Pate Applied Per Acre (Active Ingredient)*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Herbicidol-NP Kenapon Fenac-S	82.5 gal 24 lb 12 lb	May 27, 1959	"	"	80	Yard area—Size of area one acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Good control. Surviving species were blue grass (predominant), orchard grass, dock, Canada thistle (injured—growth retarded, leaves browning and plants dying) and prostrate spurge.
Herbicidol-NP Kenapon	75 gal 24 lb	May 26, 1959	"	Sweet clover, Kentucky blue grass, orchard grass, quackgrass, common ragweed, bouncing bet (small patches), curled leaf dock, blackeyed Susan, horseweed, lambsquarters, ticklegrass, horsetail (spots), wild parsnip, dogbane, bull thistle, common milkweed, field bindweed, hedge bindweed, common mullen, yarrow, fleabane daisy, Canada thislte, wild lettuce, ground cherry, cottonwood, goldenrod, giant foxtail, pigweed and Muhlenbergia spp.	10	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Evidence of good initial top kill but heavily infested during late summer with giant foxtail, ticklegrass and pigweed.
Herbicidol-NP Kenapon Atrazine[5]	75 gal 24 lb 6 lb	May 26, 1959	"	"	95	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Excellent control. Only species surviving were isolated plants of cottonwood, Canada thistle and horsetail (spot—fair top kill).
Herbicidol-NP Kenapon Atrazine	75 gal 24 lb 12 lb	May 26, 1959	"	"	95	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Excellent control. Only species surviving were isolated plants of cottonwood and Canada thistle.

TABLE 2C (Continued)

Treatment	*Pate Applied Per Acre (Active Ingredient)*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Herbicidol-NP Kenapon Telvar[6]	75 gal 24 lb 4 lb	May 26, 1959	"	"	90	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29. 1959. Very good control. Species surviving were Canada thistle, cottonwood, ground cherry and bouncing bet (healthy).
Herbicidol-NP Kenapon Telvar	75 gal 24 lb 6 lb	May 26, 1959	"	"	95	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Excellent control. Only a few plants of cottonwood surviving.
Herbicidol-NP Kenapon Telvar	75 gal 24 lb 12 lb	May 26, 1959	"	"	95	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Excellent control. A few plants of cottonwood surviving.
Herbicidol-NP Kenapon Simazine[7]	75 gal 24 lb 4 lb	May 26, 1959	"	"	25	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Evidence of good initial top kill but heavily infested with Muhlenbergia spp. during late summer. Some foxtail present.
Herbicidol-NP Kenapon Simazine	75 gal 24 lb 6 lb	May 26, 1959	"	"	90	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Very good control. Few sprigs quackgrass surviving.
Herbicidol-NP Kenapon Simazine	75 gal 24 lb 12 lb	May 26, 1959	"	"	95	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Excellent control. A few plants of Canada thistle and goldenrod surviving.
Herbicidol-NP Kenapon Karmex[8]	75 gal 24 lb 6 lb	May 26, 1959	"	"	90	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected. Oct. 29, 1959. Very good control. Canada thistle (showed slight chlorosis) and a few grass seedling surviving.

TABLE 2C (Continued)

Treatment	*Rate Applied Per Acre (Active Ingredient)*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Herbicidol-NP	75 gal	May 26, 1959	"	"	98	Yard area—Size of area 0.9 acre (13 ft wide). Ballast—cinder. Inspected Oct. 29, 1959. Excellent control.
Kenapon	24 lb					
Karmex	12 lb					

[1]Herbicidol-NP—Oil 21.40%, cresols 1.80%, xylenols 1.20%, phenols 0.50%, 2,4-Dichlorophenoxyacetic acid 1.10%, emulsifying, penetrating, binding and activating agents 12.00%, total active ingredient 45.00%, inert ingredient 55.00%.

[2]Kenapon—Diester formulation of 2,2-dichloropropionic acid containing 6 lb dalapon acid equivalent per gal.

[3]Trysben—Dimethyamine salt of trichlorobenzoic acid 24.8%, dimethylamine salt of other polychlorobenzoic acid 1.3%. Total active ingredients 26.1% (2 lb active ingredient per gal.

[5]Atrazine—2-chloro-4-isopropylamino-6-ethylamino-s-triazine 80%.

[6]Telvar—(monuron) 3-(p-chlorophenyl)-1,1-dimethylurea 80%.

[7]Simazine—2-chloro-4,6-bis-(ethylamino)-s-triazine 80%.

[8]Karmex—(diuron)-3-(3,4-dichlorophenyl)-1,1-dimethylurea 80%.

Table 2D—Results of Chemical Treatments Applied on Test Areas in Region 2

Purpose—To determine the effectiveness of various materials in controlling bouncing bet.
Size of Plots—Test 1. One-half sq rod except Silvex granular plots which were 1 sq rod.
Test 2. 1 sq rod.
Type of Vegetation—Test 1. Predominant—bouncing bet (medium to heavy infestation). Other species—Canada thistle, Russian thistle, blue grass, quackgrass, crabgrass, foxtail, wild lettuce and upright spurge.
Test. 2. Predominant—bouncing bet (heavy infestation). Other species—sunflower, milkweed, aster, big bluestem, ground cherry, wild buckwheat, wild four-o'clock, goldenrod and ragweed.
Weather Data—Test 1. University of Chicago Station: Avg Max Temp—1959—May—73.3°, June—77.9°, July—80.7°, Aug.—83.8°, Sept.—76.0°. Precipitation—Annual 1958—24.85″. Departure from Avg. (—7.39″). 1959—May—5.09″, June—2.91″, July—6.07″, Aug.—1.62″, Sept.—2.00″.
Test 2. Chicago Air Port Station: Avg Max Temp—1959—May—75.9°, June—82.6°, July—84.5°, Aug.—87.3°, Sept.—78.3°. Precipitation—Annual 1958—26.35″. Departure from Avg. (—6.37″). 1959—May—3.87″, June—5.94″, July—4.77″, Aug.—1.63″, Sept.—2.17″.
Date Inspected—September 17–18, 1959.
Description of Area—Test 1. Roadway embankment containing large quantity of cinders mixed with soil.
Test. 2. Abandoned track area. Terrain level. Soil.

Treatment	*Rate Applied Per Acre (*Denoted lb Active Ingredient)*	*Date Applied*		*Percent Control*		*Remarks*
		Test 1	*Test 2*	*Test 1*	*Test 2*	
Silvex Granular[1]	50 lb	May 29, 1959	July 2, 1959	5	25	Test 1—Lower leaves bouncing bet appeared to be slightly injured. Russian thistle and upright spurge infested area. Test 2—Some reduction bouncing bet. Heavy infestation sunflower.
Silvex Granulax	75 lb	May 29, 1959	July 2, 1959	10	40	Test 1—Heavy growth bouncing bet, apparently slightly injured. Some Canada thistle and Russian thistle survived. Test 2—Bouncing bet injured and stand reduced. Sunflower infested area and survived.
Silvex Granular	100 lb	May 29, 1959	July 2, 1959	30	60	Test 1—Some reduction bouncing bet stand. Canada thistle and Russian thistle infested this area and survived. Test 2—Severely injured and reduced stand bouncing bet. Sunflower infested area and survived.
Trysben 200 Liquid[2]	5 lb*	May 29, 1959	----------	60	--------	Test 1—Good top kill bouncing bet. Some bouncing bet and Canada thistle resprouted. Foxtail and upright spurge infested area during late summer.
Trysben 200 Liquid	10 lb*	May 29, 1959	July 2, 1959	95	60	Test 1—Excellent top kill Few bouncing bet plants resprouted from roots. Upright spurge, Russian thistle, foxtail and blue grass infested area. Test 2—Good top kill with reduction of bouncing bet stand. Milkweed and big bluestem survived.
Trysben 200 Liquid	15 lb*	May 29, 1959	July 2, 1959	95	75	Test 1—Excellent kill bouncing bet. Few plants resprouted. Lily (water), foxtail, blue grass and Canada thistle survived. Test 2—Very good top kill bouncing bet. Some regrowth bouncing bet. Controlled other species.
Trysben Granular[3]	20 lb	May 29, 1959	----------	25	--------	Test 1—Slight injury bouncing bet. Quackgrass survived in area.

TABLE 2D (Continued)

Treatment	Rate Applied Per Acre (*Denoted lb Active Ingredient)	Date Applied		Percent Control		Remarks
		Test 1	Test 2	Test 1	Test 2	
Trysben Granular	40 lb	May 29, 1959	.....	50	.....	Test 1—Bouncing bet plants injured with some reduction in stand. Crabgrass and upright spurge infested area during late summer.
Trysben Granular	60 lb	May 29, 1959	.....	65	.....	Test 1—Bouncing bet plants severely chlorotic and appeared to be dying. Blue grass survived.
DB Granular[4]	1280 lb	May 29, 1959	Aug. 7, 1959	85	65	Test 1—Very good kill bouncing bet. Some regrowth around edge of area. Test 2—Severely injured bouncing bet and other species. Bouncing bet appeared to be dying.
Benzabor[5]	160 lb	May 29, 1959	Aug. 7, 1959	80	45	Test 1—Some bouncing bet survived but is severely injured. Russian thistle injured. Other species controlled. Test 2—Severely injured all species. Bouncing bet appeared to be dying. Too early to determine complete results.
Benzabor	240 lb	May 29, 1959	Aug. 7, 1959	70	75	Test 1—Bouncing bet severely injured and appeared to be dying. Canada thistle appeared to be dying. Annuals controlled. Test 2—Bouncing bet severely injured and dying. Other species controlled.
XPI-62[6]	435 lb	May 29, 1959	Aug. 7, 1959	50	50	Test 1—Some reduction bouncing bet stand with remaining plants injured. Foxtail grass controlled. Crabgrass and upright spurge survived. Test 2—Bouncing bet severely injured. Too early to determine complete control.
XPI-62	870 lb	May 29, 1959	Aug. 7, 1959	70	75	Test 1—Bouncing bet severely injured and dying. Other species controlled. Test 2—Bouncing bet severely injured and appeared to be dying. Too early to determine complete results.
XPI-63[7]	435 lb	May 29, 1959	Aug. 7, 1959	50	45	Test 1—Bouncing bet plants severely injured and appeared to be dying. Annual species controlled. Test 2—Bouncing bet severely injured. Ground cherry survived. Sunflower injured. Too early to determine complete results.
XPI-63	870 lb	May 29, 1959	Aug. 7, 1959	70	10	Test 1—Bouncing bet plants severely injured, chlorotic and appeared to be dying. Annual species controlled. Blue grass survived. Test 2—Bouncing bet and sunflower injured. Too early to determine complete results.
Forron[8]	4 lb*	May 29, 1959	July 2, 1959	50	25	Test 1—Very good top kill bouncing bet. Bouncing bet resprouted and appeared healthy. Crabgrass and milkweed infested area during late summer. Test 2—Good top kill bouncing bet but approximately 75 percent resprouted. Other species controlled.

TABLE 2D (Continued)

Treatment	Rate Applied Per Acre (*Denoted lb Active Ingredient)	Date Applied		Percent Control		Remarks
		Test 1	Test 2	Test 1	Test 2	
Forron	6 lb*	May 29, 1959	July 2, 1959	65	25	Test 1—Very good top kill but bouncing bet resprouted and appeared healthy. Crabgrass infested area during late summer. Blue grass survived. Test 2—Good top kill bouncing bet but heavy regrowth from root system.
Forron	8 lb*	May 29, 1959	July 2, 1959	75	45	Test 1—Very good top kill. Some bouncing bet resprouted and appeared healthy. Canada thistle survived. Crabgrass infested area during late summer. Test 2—Very good top kill but considerable regrowth bouncing bet. Other species controlled.
Kuron[9]	4 lb*	May 29, 1959	July 2, 1959	35	55	Test 1—Good top burn. Considerable regrowth bouncing bet which appeared healthy. Foxtail infested area during late summer. Test 2—Good top kill bouncing bet but considerable regrowth. Other species controlled, except wild buckwheat.
Kuron	6 lb*	May 29, 1959	July 2, 1959	45	30	Test 1—Good top kill but bouncing bet resprouted and appeared healthy. Annuals controlled. Test 2—Good top kill bouncing bet but heavy regrowth.
Kuron	8 lb*	May 29, 1959	July 2, 1959	65	15	Test 1—Very good top kill bouncing bet. Some plants survived and appeared healthy. Foxtail controlled. Crabgrass and Canada thistle survived. Test 2—Good top kill bouncing bet but heavy regrowth.
TBA[10] Ata[11]	2 lb* 2 lb*	May 29, 1959	July 2, 1959	30	15	Test 1—Evidence of top burn but bouncing bet plants resprouted and appeared healthy. Some crabgrass and Canada thistle in area. Test 2—Good top burn bouncing bet but heavy regrowth.
TBA ATA	3 lb* 3 lb*	---------	July 2, 1959	--------	10	Test 2—Good top burn but heavy regrowth bouncing bet. Other species controlled.
TBA ATA	4 lb* 4 lb*	---------	July 2, 1959	--------	10	Test 2—Good top burn but heavy regrowth bouncing bet. Other species controlled.
TBA ATA	5 lb* 5 lb*	---------	July 2, 1959	--------	20	Test 2—Very good top kill bouncing bet but heavy regrowth.
Dybar[12]	80 lb	May 29, 1959	July 2, 1959	50	25	Test 1—Bouncing bet injured and chlorotic. Crabgrass infested area during late summer. Test 2—Bouncing bet showed signs of injury. Other species controlled.
Dybar	120 lb	May 29, 1959	July 2, 1959	55	65	Test 1—Bouncing bet plants severely injured, definite urea symptoms. Grasses controlled. Toothed spurge and upright spurge infested area during late summer. Test 2—Bouncing bet severely injured.

TABLE 2D (Continued)

Treatment	Rate Applied Per Acre (*Denoted lb Active Ingredient)	Date Applied		Percent Control		Remarks
		Test 1	Test 2	Test 1	Test 2	
Atlacide-2,4-D[13]	652 lb	.....	July 2, 1959	.	55	Test 2—Very good initial kill. Some bouncing bet resprouted from roots.
Atlacide-2,4-D	870 lb	.....	July 2, 1959	.	75	Test 2—Very good initial kill. Few plants of bouncing bet resprouted from roots.
Atlacide-2,4-D	1740 lb	.....	July 2, 1959	.	90	Test 2—Very good control bouncing bet. Only few plants emerged from root system.
Ureabor[14]	435 lb	.....	Aug. 7, 1959	.....	30	Test 2—Bouncing bet injured. Goldenrod and milkweed survived. Too early to determine complete results.
Ureabor	870 lb	.	Aug. 7, 1959	.....	10	Test 2—Severely injured bouncing bet. Too early to determine complete results.

[1]Silvex Granular— 2-(2,4,5-trichlorophenoxy) propionic acid 25%.
[2]Trysben 200 Liquid—Dimethylamine salt of trichlorobenzoic acid 24.8%, dimethylamine salt of other polychlorobenzoic acid 1.3%. Total active ingredients 26.1% (2 lb acid equivalent per gal).
[3]Trysben Granular—Trichlorobenzoic acid 25%.
[4]DB Granular—Disodium tetraborate pentahydrate 55%, disodium tetraborate decahydrate 35.5%, 2,4-Dichlorophenoxyacetic acid equivalent 7.5%.
[5]Benzabor—Disodium tetraborate pentahydrate 54.5%, disodium tetraborate decahydrate 35.5%, trichlorobenzoic acid 8%.
[6]XPI-62—Experimental material.
[7]XPI-63—Experimental material.
[8]Forron—Contains 2 lb acid equivalent of silvex as the propylene glycol butyl ethyl ester in a forron type formulation.
[9]Kuron—2-(2,4,5-Trichlorophenoxy) propionic acid, propylene glycol butyl ether ester 64.5%, 2-(2,4,5-Trichlorophenoxy) propionic acid equivalent 42.8% or 4 lb silvex acid equivalent.
[10]TBA—2,3,6-Trichlorobenzoic acid 2 lb per gal acid equivalent.
[11]ATA—3-amino-1,2,4-triazole 50% active ingredient.
[12]Dybar—(fenuron) 3-phenyl-1,1-dimethylurea 25% active ingredient.
[13]Atlacide-2,4-D—Sodium chlorate 58%, 2,4-Dichlorophenoxyacetic acid 0.60%, inert ingredients 41.40%.
[14]Ureabor—Disodium tetraborate pentahydrate 63.2%, disodium tetraborate decahydrate 30.8%, 3-(p-chlorophenyl)-1,1-dimethylurea 4%.

TABLE 2E—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 2

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Rep 1	Rep 2	Rep 3	
Chlorax[1]	50 gal	July 1, 1959	Park Forest, Illinois Station: Avg Max Temp—1959—Jan.—27.1°, Feb.—34.7°, Mar.—45.9°, Apr.—58.4°, May—75.0°, June—82.0°, July—84.1°, Aug.—86.7°, Sept.—78.4°. Precipitation: Annual—1958—32.38″, 1959—Jan.— , Feb.— , Mar.—3.43″, Apr.—4.30″, May—6.71″, June—1.40″, July—6.15″, Aug.—1.31″, Sept.—3.51″.	Bouncing bet	10	10	------	Inspected Oct. 13, 1959. Good top kill but heavy regrowth 6 to 10 in high.
58 CS 11[2]	4 lb	July 1, 1959	"	"	10	10	15	Inspected Oct. 13, 1959. Good top kill. Heavy regrowth 8 to 12 in high. Leaves distorted on some plants Rep 3.
58 CS 11	8 lb	July 1, 1959	"	"	20	25	------	Inspected Oct. 13, 1959. Good top kill. Some kill but heavy regrowth 4 to 8 in high.
Chlorax 58 CS 11	50 gal 4 lb	July 1, 1959	"	"	25	25	------	Inspected Oct. 13, 1959. Very good top kill. Some kill but regrowth from roots 6 to 8 in high. Slight distortion of leaves in Rep 2.
Chlorax 58 CS 11	50 gal 8 lb	July 1, 1959	"	"	10	10	------	Inspected Oct. 13, 1959. Very good top kill but heavy regrowth 4 to 8 in high.
Chlorax 58 CS 11	50 gal 16 lb	July 1, 1959	"	"	30	------	------	Inspected Oct. 13, 1959. Very good top kill with some root kill. Approximately 70 percent regrowth 8 in high.
Chlorax 58 CS 11	50 gal 20 lb	July 1, 1959	"	"	20	------	------	Inspected Oct. 13, 1959. Very good top kill but heavy regrowth 8 to 10 in high. Plants appeared healthy.
58 CS 11	4 lb	July 1, 1959	"	Goldenrod	90	------	------	Inspected Oct. 13, 1959. Very good kill. Few plants along edge of plot.
58 CS 11	8 lb	July 1, 1959	"	"	80	------	------	Inspected Oct. 13, 1959. Excellent top kill. Evidence of some roots surviving edge of plot.

TABLE 2E (Continued)

Treatment	Rate Applied Per Acre	Date Applied	Weather Data	Type of Vegetation	Percent Control			Remarks
					Rep 1	Rep 2	Rep 3	
58 CS 11	10 lb	July 1, 1959	"	Field bindweed	95	------	------	Inspected Oct. 13, 1959. Very good top kill. Approximately 5 percent regrowth.
Chlorax 58 CS 11	50 gal 10 lb	July 1, 1959	"	"	80	------	------	Inspected Oct. 13, 1959. Very good top kill. Approximately 20 percent regrowth edges of plot.
Chlorax	50 gal	July 1, 1959	"	Horsetail (spore bearing or reproductive shoots)	70	70	50	Inspected Oct. 13, 1959. Very good top kill. Considerable regrowth especially in Rep 3.
58 CS 11	4 lb	July 1, 1959	"	"	30	30	20	Inspected Oct. 13, 1959. Evidence of top kill but heavy regrowth.
58 CS 11	8 lb	July 1, 1959	"	"	30	40	20	Inspected Oct. 13, 1959. Evidence of top burn but plots heavily reinfested.
58 CS 11	16 lb	July 1, 1959	"	"	80	70	80	Inspected Oct. 13, 1959. Very good top kill. Some regrowth.
Chlorax 58 CS 11	50 gal 4 lb	July 1, 1959	"	"	85	85	20	Inspected Oct. 13, 1959. Very good control Reps 1 and 2. Evidence of top burn but heavy regrowth Rep 3.
Chlorax 58 CS 11	50 gal 8 lb	July 1, 1959	"	"	90	90	85	Inspected Oct. 13, 1959. Very good kill with some regrowth.
Chlorax 58 CS 11	50 gal 16 lb	July 1, 1959	"	"	90	95	95	Inspected Oct. 13, 1959. Excellent top kill. Very little regrowth.

[1]Chlorax—Sodium chlorate 18.2%, sodium metaborate* 10%, inert ingredient 71.8%.
*Equivalent to 1.67% boron as expressed as element boron.
[2]58 CS 11—Experimental material.

Table 3A—Results of Chemical Treatments Applied on Test Areas in Region 3

Size of Test Plots—16½ ft wide—1/20 acre.
Type of Vegetation—Predominant species: Bermuda grass, Johnson grass and nut grass. Other species: trumpet vine, crabgrass, foxtail, prostrate spurge, dewberry, false golden aster, bitter weed, dandelion, three-seeded mercury, dogbane, oxalis, Dallis grass, blackberry and dock.
Date of Application—February 25, 1959 (Pre-emergence application—dry materials). May 29, 1959 (Post-emergence application—liquid solutions).
Weather Data—Shreveport, Louisiana Station: Avg Max Temp—1959—Jan.—56.2°, Feb.—60.0°, Mar.—68.5°, Apr.—73.1°, May—85.0°, June—88.1°, July—91.3°, Aug.—92.°, Sept.—88.4°. Precipitation: Annual—1958—46.75″. Departure from Avg—(1.65″). 1959—Jan.—1.17″, Feb.—4.79″, Mar.—2.82″, Apr.—3.58″, May—3.23″, June—3.35″, July—3.29″, Aug.—2.13″, Sept.—1.64″.
Date Inspected—July 22, 1959.

Treatment	*Rate Applied Per Acre*	*Percent Control*	*Remarks*
Soil Sterilant[1]	150 lb	85	Pre-emergence application—dry material. Results—Very good control. Some sprigs Bermuda grass, nut grass, Johnson grass and trumpet vine survived. Trumpet vine leaves slightly chlorotic.
Soil Sterilant	200 lb	90	Pre-emergence application—dry material. Results—Very good control. Spots of Bermuda grass and Johnson grass survived. Bermuda grass appeared to be injured. Other species present were nut grass, trumpet vine (leaves chlorotic), dewberry, prostrate spurge and Dallis grass.
Telvar[2] TCA[3]	20 lb 100 lb	60	Pre-emergence application—dry material. Results—Fair control. Appeared to retard growth of Bermuda grass and Johnson grass. Other species such as trumpet vine (resistant), nut grass (resistant), crabgrass, foxtail, dewberry and prostrate spurge infested area.
Fenac[4] TCA	5 lb 100 lb	20	Pre-emergence application—dry material. Results—Poor control. Appeared to provide initial kill but heavily reinfested with Bermuda grass, false golden aster, bitter weed, crabgrass, dandelion, three-seeded mercury and Dallis grass.
Fenac TCA	10 lb 100 lb	25	Pre-emergence application—dry material. Results—Poor control. Initial kill but approximately 75 percent regrowth of Bermuda grass and Johnson grass. Some dogbane, oxalis and upright spurge infested area.
Fenac TCA	20 lb 100 lb	10	Pre-emergence application—dry material. Results—Poor control. Heavy growth Bermuda grass and Johnson grass. Some upright spurge, oxalis and Dallis grass infested area.
Fenac TCA Telvar	5 lb 80 lb 20 lb	10	Pre-emergence application—dry material. Results—Poor control. Heavy infestation of Bermuda grass, Johnson grass and nut grass. Bermuda grass appeared to be injured. Some prostrate spurge in area.
Fenac TCA Telvar	10 lb 80 lb 20 lb	60	Pre-emergence application—dry material. Results—Fair control. Johnson grass and nut grass appeared to be resistant. Bermuda grass intermediately susceptible—some regrowth. Prostrate spurge in area.
Fenac Telvar TCA	20 lb 20 lb 80 lb	60	Pre-emergence application—dry material. Results—Fair control. Bermuda grass injured. Johnson grass, nut grass and trumpet vine resistant. Prostrate spurge present in area.

TABLE 3A (Continued)

Treatment	*Rate Applied Per Acre*	*Percent Control*	*Remarks*
Simazine[5]	20 lb	80	Pre-emergence application—dry material.
TCA	80 lb		Results—Good control. Bermuda grass and Johnson grass appeared to be intermediately susceptible—some regrowth. Nut grass and dewberry resistant.
Telvar	20 lb		
Simazine	20 lb	45	Pre-emergence application—dry material.
Telvar	20 lb		Results—Poor control. Johnson grass growth rank. Bermuda grass retarded—some regrowth. Trumpet vine leaves slightly chlorotic.
Fenac	5 lb	20	Pre-emergence application—dry material.
Simazine	20 lb		Results—Poor control. Heavy infestation Bermuda grass and Johnson grass.
TCA	80 lb		
Sodium chlorate[6]	200 lb	85	Post-emergence application—liquid solution.
Fenac[7]	4 lb		Results—Very good control Bermuda grass. Some regrowth Johnson grass, nut grass and blackberry.
Sodium chlorate	200 lb	85	Post-emergence application—liquid solution.
Fenac	2 lb		Results—Very good control. Some regrowth Bermuda grass, Johnson grass, trumpet vine (injured) and dock.
Methoxy propazine[8]	10 lb	90	Post-emergence application—liquid solution.
Telvar	20 lb		Results—Very good control. Sprigs Bermuda grass survived. Inhibited growth trumpet vine and dewberry. Dock survived.
Fenac	8 lb	90	Post-emergence application—liquid solution.
Sodium chlorate	200 lb		Results—Very good control. Bermuda grass killed. Trumpet vine injured.
Methoxy propazine	10 lb	80	Post-emergence application—liquid solution.
Simazine	20 lb		Results—Good control. Good top kill Bermuda grass but some resprouting. Some Johnson grass (spots), trumpet vine and dewberry survived.
Methoxy propazine	15 lb	75	Post-emergence application—liquid solution.
			Results—Fair control. Good top kill Bermuda grass and Johnson grass but some regrowth. Trumpet vine and dewberry injured—leaves slightly chlorotic.
Sodium chlorate	200 lb	90	Post-emergence application—liquid solution.
Fenac	16 lb		Results—Very good control. Excellent grass kill. Inhibited growth of trumpet vine.
Methoxy propazine	10 lb	60	Post-emergence application—liquid solution.
			Results—Fair control. Bermuda grass, Johnson grass and dewberry infested area.

[1]Soil Sterilant—3-(p-chlorophenyl)-1,1-dimethylurea 21.33%, inert ingredient 78.6%.
[2]Telvar—3-(p-chlorophenyl)-1,1-dimethylurea 80%.
[3]TCA—Trichloroacetic acid.
[4]Fenac—Amide formulation 2,3,6-Trichlorophenylacetic acid 40% active ingredient.
[5]Simazine—2-chloro-4,6-bis-(ethylamino)-s-triazine 80%.
[6]Sodium chlorate—Sodium chlorate.
[7]Fenac—Sodium salt-2,3,6-Trichlorophenylacetic acid 1.5 lb acid equivalent per gal.
[8]Methoxy propazine—2-methoxy-4,6-bis (isopropylamino)-s-triazine.

TABLE 3B—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 3

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Soil Sterilant[1]	150 lb	March 12, 1959	Norfolk, Virginia Airport Station: Avg Max Temp: 1959—Jan.—49.1°, Feb.—52.4°, Mar.—59.2°, Apr.—71.0°, May—79.7°, June—86.2°, July—85.7°, Aug.—88.5°, Sept.—81.3°. Precipitation: Annual—1958—57.78″. Departure from Avg—(14.52″). 1959—Jan.—1.52″, Feb.—1.84″, Mar.—3.96″, Apr.—5.03″, May—1.98″, June—2.48″, July—7.49″, Aug.—2.81″, Sept.—10.73″.	Predominant species: Bermuda grass, trumpet vine, crabgrass and triple awned grass. Other species: broom sedge, goldenrod, prostrate spurge, upright spurge, narrow leaf plantain, ticklegrass, aster, ragweed, mullen, peppergrass, field bindweed, Johnson grass, nut grass, lovegrass Panicum spp. and Cyprus spp.	75–80	Inspected Oct. 22, 1959. Yard area—between tracks only. Ballast—cinder and soil. Size of area 10 acres. Results—Very good control annual species. Fair to good control Bermuda grass. Some Bermuda grass encroached beneath rails from between rails and infested spots of area. Some sprigs of Bermuda appeared chlorotic. Trumpet vine survived and maintained vigorous growth. Evidence of slight chlorosis in some leaves.
Urox 22[2]	150 lb	March 17, 1959	"	"	70–80	Inspected Oct. 22, 1959. Yard area—between tracks only. Ballast—cinder and soil. Size of area 10 acres. Results—Very good control annual species. Control poor to fair in areas heavily infested with Bermuda grass and trumpet vine. Approximately 25 percent reduction Bermuda grass. Trumpet vine maintained vigorous growth with slight chlorosis evident in some plants. Few crabgrass seedlings infested area along rails.
Ureabor[3]	650 lb	March 24-26, 1959	"	Predominant species: Annuals—crabgrass, triple awned grass. Other species: broom sedge, nut grass, Johnson grass, goldenrod, prostrate spurge, narrow leaf plantain, ticklegrass, aster, ragweed, mullen, peppergrass, Panicum spp. and field bindweed.	75–95	Inspected Oct. 22, 1959. Yard area—between tracks only. Ballast—cinder, soil and coal dust. Size of area 30 acres. Results—Very good control annuals species. Broom sedge, nut grass and spots of Johnson grass survived. Some crabgrass infested area along rails. Prostrate spurge germinated during late summer.
Nalco H-174[4]	400 lb	March 31, 1959	"	Predominant species: Annuals—crabgrass, lovegrass and ragweed. Other species: Cyprus spp., trumpet vine and broom sedge.	95	Inspected Oct. 22, 1959. Yard area—between tracks only. Ballast—cinder, soil and coal dust. Size of area 30 acres. Results—Very good control annuals species. Trumpet vine and Cyprus spp. survived.
Nalco H-174	400 lb	March 31, 1959	"	Predominant species: Bermuda grass. Other species: crabgrass and nut grass.	75	Inspected Oct. 22, 1959. Yard area—between tracks only. Ballast—cinder and soil. Results—Fair control Bermuda grass. Spots Bermuda grass and nut grass survived. Crabgrass infested area along rails.

TABLE 3B (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
MC No. 2[5] plus Fenac[6]	200 gal sol. 4 lb	Aug. 24, 1959	Blytheville, Arkansas Station: Avg Max Temp—1959—Jan.—45.2°, Feb.—51.8°, Mar.—61.8°, Apr.— , May—83.9°, June—86.1°, July—88.2°, Aug.—89.6°, Sept.—84.1°. Precipitation: Annual—1958—49.28″. Departure from Avg—(2.65″). 1959—Jan.—4.63″, Feb. 7.45″, Mar.—2.44″, Apr.— , May—2.93″, June—3.09″, July—3.17″, Aug.—4.35″, Sept.—4.08″.	Predominant species: Johnson grass. Other species: trumpet vine, sweet gum and ash.	90	Inspected Oct. 7, 1959. Main line—Size of area 80 ft wide, 2 mi long. Results—Excellent top kill all species. Approximately 10 percent regrowth Johnson grass. Roots appeared to be decaying. Approximately 20 percent regrowth trumpet vine. Leaves distorted. No resprouting of sweet gum and ash.
Garlon[7]	15 gal	May, 1959	Memphis, Tennessee Airport Station: Avg Max Temp—1959—Jan.—48.9°, Feb.—53.8°, Mar.—62.9°, Apr.—71.9°, May—83.9°, June—86.8°, July—88.9°, Aug.—90.2°, Sept.—85.5°. Precipitation: Annual—1958—53.93″. Departure from Avg—(4.52″). 1959—Jan.—4.34″, Feb.—5.21″, Mar.—3.56″, Apr.—3.73″, May—1.85″, June—4.82″, July—8.84″, Aug.—4.56″, Sept.—2.73″.	Predominant species: Johnson grass. Other species: trumpet vine and Smilax spp.	75–80	Inspected July 24, 1959. Road crossings. Results—Excellent top kill Johnson grass. Approximately 20–25 percent regrowth. Johnson grass (10–12 in high). Trumpet vine and Smilax spp. survived. Some prostrate spurge emerged. According to a railroad representative approximately 50 percent Johnson grass resprouted later during season.
Radapon[8] Telvar[9]	40 lb 10 lb	May 12, 1959	"	Predominant species: Johnson grass. Other species: Bermuda grass, trumpet vine and Smilax spp.	80–85	Inspected July 24, 1959. Main line. Ballast—crushed stone. Size of area 16 ft wide, 5.9 mi long. Results—Very good control Johnson grass and Bermuda grass. Minor regrowth. Trumpet vine and Smilax spp. survived. According to a railroad representative this treatment maintained good control throughout the season.

[1]Soil Sterilant—3-(p-chlorophenyl)-1,1-dimethylurea 21.33%, inert ingredient 78.67%.
[2]Urox 22—3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate 22%.
[3]Ureabor—Disodium tetraborate pentahydrate 63.2%, disodium tetraborate decahydrate 30.8%, 3-(p-chlorophenyl)-1,1-dimethylurea 4%.
[4]Nalco H-174—3-(p-chlorophenyl)-1,1-dimethylurea 8%, sodium tetraborate 83%, inert ingredient 9.0%.
[5]MC No. 2—Sodium borate 10%, sodium chlorate 7%.
[6]Fenac—2,3,6-Trichlorophenylacetic acid 1.5 lb per gal conc. (mixture contained 0.04 lb per gal concentrate applied).
[7]Garlon—Contains diethylene glycol bis 2,2-dichloropropionate and 2-(2,4,5-trichlorophenoxy) propionic acid propylene glycol butyl ether esters.
[8]Radapon—2,2 dichloropropionic acid, 4 lb per gal 78% dalapon sodium salt.
[9]Telvar—3-(p-chlorophenyl)-1,1-dimethylurea 80%.

Table 3C—Results of Chemical Treatments Applied on Test Areas in Region 3

Size of Test Plots—16 ft wide; 1/2, 1 and 4 rails long (note under remarks).
Type of Vegetation—Predominant species: Johnson grass and Bermuda grass. Other species: dewberry, May pop., nut grass, crabgrass, dogbane, upright spurge, horsenettle, Florida pusley, Kudzu, trumpet vine, peppergrass, wild lettuce, marestail, ragweed, plantain, honeysuckle, three-seeded mercury and evening primrose.
Date of Application—March 23, 1959.
Weather Data—Atlanta, Georgia Airport Station: Avg Max Temp—1959—Jan.—52.2°, Feb.—56.2°, Mar.—61.6°, Apr.—73.2°, May—81.9°, June—90.5°, July—85.9°, Aug.—88.3°, Sept.—81.5°. Precipitation: Annual—1958—49.64″, Departure from Avg—(0.48″). 1959—Jan.—3.38″, Feb.—3.61″, Mar.—6.61″, Apr.—2.83″, May—5.35″, June—1.42″, July—1.50″, Aug.—3.27″, Sept.—3.46″.
Date Inspected—July 8, 1959.
Ballast—Primarily gravel and sand with some rock and slag.

Treatment	*Rate Applied Per Acre*	*Percent Control*		*Remarks*
		Rep 1	*Rep 2*	
XPI-29[1]	436 lb	10	70	Rep 1—One rail long. Results—Heavy infestation Bermuda grass, Johnson grass and horsenettle. Controlled only 10 percent of grasses as well as broad-leaved species. Rep 2—One rail long. Results—Fair control. Eliminated all broad-leaved species. Controlled approximately 60 percent grasses. Bermuda grass (predominant species) and Johnson grass survived.
XPI-29	872 lb	55	80	Rep 1—One rail long. Results—Fair control. Controlled approximately 90 percent broad-leaved species and 50 percent grasses. Johnson grass (predominant species) and horsenettle survived. Rep 2—One rail long. Results—Good control. Eliminated all broad-leaved species and 70 percent of grasses. Only species that survived was Bermuda grass and it was severely injured.
XPI-60[2]	218 lb	25	20	Rep 1—Four rails long. Results—Poor control. Controlled approximately 75 percent broad-leaved species but only 20 percent grasses. Area heavily infested with Johnson grass (predominant species), Bermuda grass, May pop., dogbane, crabgrass and upright spurge. Rep 2—Four rails long. Results—Poor control. Controlled only 20 percent broad-leaved species and grasses. Area heavily infested with Johnson grass (predominant species), Florida pusley, upright spurge, crabgrass and Bermuda.
XPI-60	436 lb	50	37	Rep 1—Four rails long. Results—Poor control. Controlled approximately 90 percent broad-leaved species but only 40 percent grasses. Area heavily infested with Bermuda grass and crabgrass (predominant species). Other species that survived were nut grass, dewberry, upright spurge and horsenettle. Rep 2—Four rails long. Results—Poor control. Eliminated 90 percent broad-leaved species but only 35 percent grasses. Area heavily infested with nut grass (predominant species), Johnson grass, Bermuda grass and horsenettle.
XPI-69[3]	436 lb	55	55	Rep 1—One rail long. Results—Fair control. Controlled 90 percent broad-leaved species and 50 percent grasses. Species that survived were Bermuda grass (predominant species) and Johnson grass. Rep 2—One rail long. Results—Fair control. Eliminated all broad-leaved species but only 40 percent grasses. Species that survived were Bermuda grass (predominant species) and crabgrass. Bermuda grass slightly injured.
XPI-60	872 lb	85	93	Rep 1—Four rails long. Results—Good control. Eliminated 95 percent broad-leaved species and 80 percent grasses. Species that survived were Johnson grass (predominant species), Bermuda grass and Florida pusley. Rep 2—Four rails long. Results—Very good control. Eliminated 98 percent broad-leaved species and 90 percent grasses. Species that survived were crabgrass (predominant species), Johnson grass, horsenettle, nut grass and Bermuda grass (severely injured).

TABLE 3C (Continued)

Treatment	Rate Applied Per Acre	Percent Control		Remarks
		Rep 1	Rep 2	
XPI-69	872 lb	65	90	Rep 1—One rail long. Results—Fair control. Controlled 98 percent broad-leaved species but only 60 percent grasses. Considerable growth of Bermuda grass. Some Kudzu present, encroached from outside treated area. Rep 2—One rail long. Results—Very good control. Eliminated all broad-leaved species and 80 percent grasses. Predominant species that survived were Johnson grass and crabgrass. Some nut grass and Bermuda grass present.
XPI-64[4]	218 lb	15	50	Rep 1—One rail long. Results—Poor control. Area heavily infested with Bermuda grass and trumpet vine (predominant species). Other species that survived were nut grass and Kudzu. Kudzu encroached from untreated area. Rep 2—Four rails long. Results—Poor control. Controlled approximately 50 percent broad-leaved species and grasses. Considerable regrowth of Johnson grass (predominant species) and Bermuda grass.
XPI-64	436 lb	50	20	Rep 1—Four rails long. Results—Poor control. Controlled approximately 75 percent grasses but only 20 percent broad-leaved species. Considerable growth Bermuda grass, trumpet vine, nut grass and Kudzu. Kudzu encroached from untreated area. Rep 2—Four rails long. Results—Poor control. Controlled 90 percent broad-leaved species but only 15 percent grasses. Heavy infestation Johnson grass. Some horsenettle and sprigs of Bermuda grass present.
XPI-64	872 lb	90	80	Rep 1—Four rails long. Results—Very good control. Eliminated 85 percent broad-leaved species and 95 percent grasses. Nut grass (predominant species), Bermuda grass and trumpet vine survived. Rep 2—Two rails long. Results—Good control. Eliminated all broad-leaved species and 75 percent grasses. Bermuda grass (predominant species) and Johnson grass survived.
XPI-65[5]	218 lb	10	05	Rep 1—Four rails long. Results—Poor control. Heavily infested with Johnson grass (predominant species), crabgrass, ragweed and other annuals. Rep 2—Four rails long. Results—Poor control. Grasses injured—regrowth annuals. Heavy growth Bermuda grass and crabgrass. Other species present were Johnson grass, upright spurge, peppergrass, wild lettuce, marestail, Florida pusley, ragweed, plantain and honeysuckle.
XPI-65	436 lb	20	15	Rep 1—One rail long. Results—Poor control. Heavily infested with crabgrass and other annuals. Rep 2—Four rails long. Results—Poor control. Controlled 10 percent broad-leaved species and 15 percent grasses. Heavily infested with Bermuda grass and crabgrass. Other species present were peppergrass, ragweed, upright spurge, three-seeded mercury, wild lettuce, evening primrose, Johnson grass and nut grass.
XPI-70[6]	436 lb	98	40	Rep 1—One rail long. Results—Excellent control. Few plants crabgrass and bindweed survived. Rep 2—One rail long. Results—Poor control. Controlled 90 percent broad-leaved species but only 35 percent grasses. Heavy infestation Johnson grass. Some Bermuda grass and crabgrass present.
XPI-70	872 lb	70	95	Rep 1—One rail long. Results—Fair control. Eliminated all broad-leaved species but only 65 percent grasses. Johnson grass only grass that survived. Rep 2—One rail long. Results—Very good control. Controlled 98 percent broad-leaved species and 92 percent grasses. Few plants crabgrass and horsenettle survived.

TABLE 3C (Continued)

Treatment	Rate Applied Per Acre	Percent Control		Remarks
		Rep 1	Rep 2	
XPI-70	1308 lb	85	98	Rep 1—One rail long. Results—Good control. Eliminated all broad-leaved species and controlled 85 percent of grasses. Johnson grass only species that survived. Rep 2—One rail long. Results—Excellent control. Eliminated all broad-leaved species. Only a few sprigs of Bermuda grass and Johnson grass survived.
XPI-71[7]	436 lb	98	80	Rep 1—One rail long. Results—Excellent control. Crabgrass only species in area. Rep 2—One rail long. Results—Good control. Controlled 95 percent broad-leaved species and 70 percent grasses. Bermuda grass (predominant species), crabgrass, May pop., and Johnson grass (on edge of plot) survived.
XPI-71	872 lb	98	95	Rep 1—One rail long. Results—Excellent control. Bermuda grass sprigs survived. Rep 2—One rail long. Results—Very good control. Eliminated all broad-leaved species and 90 percent grasses. Bermuda grass only species present and it was injured.
XPI-71	1308 lb	98	98	Rep 1—One rail long. Results—Excellent control. A few plants Johnson grass only species present in area. Rep 2—One rail long. Results—Excellent control. Eliminated all broad-leaved species and 95 percent grasses. Bermuda grass sprigs present but were severely injured.
XPI-75[8]	436 lb	85	85	Rep 1—One-half rail long. Results—Good control. Eliminated all broad-leaved species and 85 percent grasses. Some Bermuda grass survived. Rep 2—One-half rail long. Results—Good control. Controlled 95 percent broad-leaved species and 80 percent grasses. Bermuda grass only grass species that survived but it was injured.
XPI-75	872 lb	70	98	Rep 1—One-half rail long. Results—Fair control. Eliminated all broad-leaved species and 70 percent grasses. Nut grass only species that survived. Rep 2—One-half rail long. Results—Excellent control. Eliminated all broad-leaved species and 95 percent grasses. Bermuda grass only species that survived.
XPI-76[9]	436 lb	70	90	Rep 1—One-half rail long. Results—Fair control. Eliminated all broad-leaved species and 70 percent grasses. Some Bermuda grass (predominant species) and crabgrass survived. Rep 2—One-half rail long. Results—Very good control. Eliminated all broad-leaved species and 80 percent grasses. Some Johnson grass (predominant species), Bermuda grass and crabgrass survived.
XPI-76	872 lb	95	98	Rep 1—One-half rail long. Results—Very good control. Controlled 98 percent broad-leaved species and 95 percent grasses. Few plants Johnson grass (predominant species), Bermuda grass (severely injured) and dogbane survived. Rep 2—One-half rail long. Results—Excellent control. Eliminated all broad-leaved species and 95 percent grasses. Few spots Johnson grass survived. Note: 100 percent kill Bermuda grass.
XPI-77[10]	436 lb	70	90	Rep 1—One-half rail long. Results—Fair control. Eliminated all broad-leaved species and 70 percent grasses. Johnson grass only grass that survived. Rep 2—One-half rail long. Results—Very good control. Controlled 80 percent broad-leaved species and eliminated all grasses. Dewberry and May pop. survived.

TABLE 3C (Continued)

Treatment	Rate Applied Per Acre	Percent Control		Remarks
		Rep 1	Rep 2	
XPI-77	872 lb	98	90	Rep 1—One-half rail long. Results—Excellent control. Eliminated all broad-leaved species and 98 percent grasses. Few plants Johnson grass survived. Rep 2—One-half rail long. Results—Very good control. Controlled 80 percent broad-leaved species and eliminated all grasses. Dewberry and May pop. survived.

[1] XPI-29—Experimental material.
[2] XPI-60—Experimental material.
[3] XPI-69—Experimental material.
[4] XPI-64—Experimental material.
[5] XPI-65—Experimental material.
[6] XPI-70—Experimental material.
[7] XPI-71—Experimental material.
[8] XPI-75—Experimental material.
[9] XPI-76—Experimental material.
[10] XPI-77—Experimental material.

TABLE 4—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 4

Type of Vegetation: Predominant species: Bermuda grass, nut grass and Johnson grass. Other species: Crabgrass, sandbur, foxtail, iron weed, Dallis grass and trumpet vine.
Date of Application: May 5, 1959.
Weather Data: New Orleans, Louisiana Station: Avg Max Temp: 1959—Jan.—60.2°, Feb.—65.0°, Mar.—68.6°, Apr.—76.0°, May—85.4°, June—88.6°, July—89.3°, Aug.—90.2°, Sept.—87.1°.
Precipitation: Annual 1958—56.48″. Departure from average—(—7.06). 1959—Jan.—3.95″, Feb.—10.86″, Mar.—4.23″, Apr.—4.16″, May—12.99″, June—5.61″, July—18.16″, Aug.—5.20″, Sept.—4.15″.
Date Inspected: July 21, 1959.

Treatment	*Rate Applied Per Acre*	*Percent Control*	*Remarks*
Radapon[1]	10 lb	60	Annual species controlled. Reduced stand of perennial species approximately 50 percent. Bermuda grass, nut grass and a few sprigs of Johnson grass survived.
Karmex[2]	10 lb		
Radapon	20 lb	85	Annual species controlled except a few isolated plants sandbur and foxtail. Bermuda grass sprigs survived but were injured. Nut grass reinfested area. Some trumpet vine and Dallis grass survived.
Karmex	20 lb		

[1]Radapon—2,2-dichloropropionic acid, 4 lb per gal 78% dalapon sodium salt.
[2]Karmex—3-(3,4-dichlorophenyl)-1,1-dimethylurea 80%.

Table 5A—Cooperative Weed Control Test in Region 5

Application Dates:
Original Application—June 11-24, 1956.
Re-treated—June 9-25, 1957
Re-treated—June 2-12, 1958
Re-treated—June 14-24, 1959

Inspection Dates:
August 20-23, 1956
May 14-16, 1957
September 10-12, 1957
October 1-2, 1958
September 2, 1959

Vegetation: Predominant species—smooth brome grass, blue grass and quackgrass. Other species—smartweed, milkweed, horsetail, willow, buckbrush, knotweed, foxtail grass, wild roses and Mexican fireweed.

Weather Data: Grand Forks, North Dakota University Station—Avg Max Temp: 1957—Jan.—10.8°, Feb.—20°, Mar.—35.8°, Apr.—52.7°, May—69.5°, June—73°, July 86.6°, Aug.—79.5°, Sept.—64.5°, Oct.—54.0°, Nov.—33.6°, Dec.—28.3°. 1958—Jan.—25.3°, Feb.—21.6°, Mar.—40.0°, Apr.—57.3°, May—72.2°, June— , July—78.1°, Aug.—81.1°, Sept.—71.7°, Oct.—58.7°, Nov.—36.5°, Dec.—15.3°. 1959—Jan.—8.2°, Feb.—15.8°, Mar.—37.0°, Apr.—54.6°, May—65.7° June—78.6°, July—82.6°, Aug.—82.8°, Sept.—68.6°.

Precipitation: 1957—Jan.—0.30″, Feb.—0.51″, Mar.—0.13″, Apr.—0.98″, May—3.21″, June—3.78″, July—2.20″, Aug.—4.04″, Sept.—7.54″, Oct.—1.94″, Nov.—0.93″, Dec.—0.11″. Annual—1957—25.67″. Departure from Avg (5.62″). 1958—Jan.—0.09″, Feb.—0.19″, Mar.—0.18″, Apr.—0.75″, May—1.31″, June—2.85″, July—5.09″, Aug.—1.32″, Sept.—1.24″, Oct.—1.23″, Nov.—3.16″, Dec.—0.41″. Annual—1958—17.82. Departure from Avg (—2.23″). 1959—Jan.—0.25″, Feb.—0.62″, Mar.—0.09″, Apr.—0.23″, May—2.96″, June—3.73″, July—3.51″, Aug.—2.94″, Sept.—1.14″.

Test No.	*Treatment*	*Rate Applied Per Acre*	*Miles Treated*	*Remarks*
1	Radapon (dalapon)[1]-Methoxone (MCP)[2]	32.5 lb-1.63 lb 36.29 lb-1.81 lb 39.07 lb-1.95 lb 58.68 lb-2.93 lb	12.0 26.5 67.12	Very good control during 1956 season.
	Re-treated 1957 with Radapon 2,4-D[3]	40 lb 6 lb	105.62	Results fair to good May 14, 1957. Initial control following re-treatment fair. Considerable regrowth occurred on this line by Sept., 1957. Species that reinfested this area were Mexican fireweed, knotweed, horsetail, foxtail and prostrate spurge. Some blue grass and brome grass survived.
	Re-treated 1958 with Methoxone-Chlorea 48[4]	51.79 gal conc	105.62	Very good to excellent control on October 1, 1958 (85 to 90 percent control). Some areas spotty with brome grass, blue grass and dandelion.
	Re-treated 1959 with Methoxone-Chlorea 48	51.79 gal conc	105.62	Results excellent when inspected September 2, 1959. Percent control estimated to be 95 to 98 percent. Only a few isolated plants of smartweed, wild rose and milkweed that survived.
2	Radapon (dalapon)-Methoxone-Chlorax No. 2[5]	20.64 lb-93.35 gal 21.24 lb-95.59 gal 19.44 lb-87.52 gal 17.18 lb-77.34 gal	31.0 4.0 33.16 20.36	Excellent control during 1956 season.
	Re-treated 1957 with Methoxone-Chlorea 800[6]	185 gal sol	88.52	Good control on May 14, 1957. Results very good to excellent Sept. 1957. Spots of blue grass survived but was chlorotic. Absence of annuals on this line.

TABLE 5A (Continued)

Test No.	Treatment	Rate Applied Per Acre	Miles Treated	Remarks
	Not treated 1958			Very good control on October 1, 1958. Some brome grass encroached along edge.
	Re-treated 1959 with Methoxone-Chlorax plus Simazine[7]	51.79 gal conc 6.0 lb	88.52	Results excellent when inspected September 2, 1959. Percent control estimated to be 95 to 98 percent. Only a few isolated plants of smartweed and buckbrush survived.
3	Radapon-Methoxone Liquid plus Monuron (Telvar W)[8]	7.46–1.50–9.50*lb 9.66–1.93–7.78*lb 10.88–2.17–6.73*lb	25.87 18.13 28.37	Very good control during 1956 season.
	Re-treated 1957 with Methoxone-Chlorea 800	195 gal sol	72.37	Very good control on May 14, 1957. Control excellent Sept. 1957. No appreciable regrowth.
	Not treated 1958			Very good to excellent control on October 1, 1958 (85 to 90 percent control). Brome grass encroached along edge.
	Re-treated 1959 with Methoxone-Chlorea 46[9]	51.79 gal conc	72.37	Results excellent when inspected September 2, 1959. Percent control estimated to be 95 percent. Only a few plants smartweed and buckbrush survived.

[1]Radapon (dalapon)—2,2-dichloropropionic acid, 4 lb per gal 78% dalapon sodium salt.
[2]Methoxone (MCP)—2-methyl-4-chlorophenoxyacetic acid 2 lb acid equivalent per gal.
[3]2,4-D—2,4-Dichlorophenoxyacetic acid 4 lb acid equivalent oer gal.
[4]Methoxone-Chlorea 48—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%, Telvar (monuron) 1.6%.
[5]Methoxone-Chlorax No. 2—Sodium chlorate 16.3%, sodium metaborate 9.1%, 2-methyl-4-chlorophenoxyacetic acid 0.2%, inert ingredient 74.4%.
[6]Methoxone-Chlorea 800—Sodium chlorate 16.3%, sodium metaborate 9.1%, 2-methyl-4-chlorophenoxyacetic acid 0.4%, Telvar equivalent .16 lb per gal conc.
[7]Simazine—2-chloro-4,6-bis-(ethylamino)-s-triazine 80%.
[8]Telvar W—3-(p-chlorophenyl)-1,1-dimethylurea 80%.
[9]Methoxone-Chlorea 46—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%, Telvar equivalent 1.2%.

TABLE 5B—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 5

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*		*Remarks*
					Oct. 3, 1958	*Aug. 31, 1959*	
Ammate X[1] Telvar W[2] Trysben 200[3]	60 lb 10 lb 0.5 lb	June 19, 1958	Jamestown, North Dakota Airport Station: Avg Max Temp: 1958—June— , July—78.2°, Aug.—84.2°, Sept.—72.5°, Oct.—61.7°, Nov.—39.0°, Dec.—22.4°. 1959—Jan.—14.3°, Feb.—20.8°, Mar.—44.5°, Apr.—57.0°, May—64.3°, June—78.9°, July—84.7°, Aug.—86.4°, Sept.-69.3° Precipitation: 1958—June—4.70″, July—2.35″, Aug.—1.41″, Sept.—0.85″, Oct.—0.55″, Nov.—0.77″, Dec.—0.11″. Annual—1958—16.33″. Departure from Avg—(0.0″). 1959—Jan.—0.13″, Feb.—0.22″, Mar.—0.11″, Apr.—0.10″, May—5.52″, June—3.82″, July—3.26″, Aug.—2.36″, Sept.—1.82″.	Wild barley, bladder campion, wild rose, mustard, smartweed, Mexican fireweed, frenchweed, marestail, goatsbeard, small sage, sweet clover, milkweed, quackgrass, smooth brome grass, blue grass, sunflower, cheat grass, kinghead and dandelion.	70	20	Branch Line—Ballast gravel. Results 1959—Controlled grasses. Heavily infested with Russian thistle, five-hook Bassia, Mexican fireweed and smartweed. Approximately 90 percent of infestation was Russian thistle and five-hook Bassia.
Methoxone-Chlorax[4] Telvar W	50 gal 8 lb	June 19, 1958	"	"	90	80–85	Branch Line— Ballast gravel. Results 1959—Good control Grasses controlled. Only species that survived were wild rose (predominant species), few plants Russian thistle and Mexican fireweed.
Methoxone-Chlorax Telvar W Trysben 200	50 gal 6 lb 1.0 lb	June 19, 1958	"	"	95	75–80	Branch Line—Ballast gravel. Results 1959—Good control. Grasses controlled. Species that reinfested area were fireweed, five-hook Bassia and smartweed.

[1]Ammate X—Ammonium sulfamate 95%.
[2]Telvar W—3-(p-chlorophenyl)-1,1-dimethylurea 80%.
[3]Trysben 200—Dimethylamine salt of trichlorobenzoic acid 24.8%, dimethylamine salt of other polychlorobenzoic acid 1.3%, Total active ingredients 26.1%.
[4]Methoxone-Chlorax—Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%.

TABLE 5B (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent* Control *Aug. 20, 1959*	*Remarks*
Monobor-chlorate No. 6[5] plus Fenac[6]	51 gal 3 lb	May 12, 1959	Great Falls, Montana Station: Avg Max Temp: 1959—Jan.—34.3°, Feb.—27.0°, Mar.—46.9°, Apr.—.54.4°, May—59.5°, June—74.9°, July—85.1°, Aug.—78.4°, Sept.—66.1°. Precipitation: 1958—Annual—16.14″. Departure from Avg—(2.11″). Jan.—1.57″, Feb.—1.00″, Mar.—0.58″, Apr.—0.36″, May—2.94″, June—1.88″, July—0.04″, Aug.—0.37″, Sept.—1.55″.	Predominant species: Blue grass, buckbrush and milkweed. Other species: Cheat grass, salt grass, wild oats, Canada rye, bunch grass, Mexican fireweed, wild four-o'clock, mullen, evening primrose, Russian thistle, wild mustard, wild lettuce, smut grass, aster, and yellow sweet clover.	75	Main line—Width 20 ft. Ballast—combination gravel, soil and cinder. Good control when inspected Aug. 20, 1959. Ballast area relatively clean. Blue grass predominant species that survived but it was slightly injured. Some buckbrush, milkweed (slightly injured) and an unidentified vine also survived.
Monobor-chlorate No. 6 plus Fenac	51 gal 6 lb	May 12, 1959	"	"	85	Main line—Width 20 ft. Ballast—Combination gravel, soil and cinder. Results good when inspected Aug. 20, 1959. Ballast relatively clean. Very good top kill. Very little grass in this area. Some blue grass along edge of ballast and it survived. Other species present were horsetail (slightly injured), wild licorice (healthy), cedar (top burn), vine unidentified (injured) and buckbrush (slightly injured). Note: pine tree edge of treated area killed.
Monobor-chlorate No. 6 plus TBA[7]	51 gal 3 lb	May 20, 1959	"	Quackgrass, blue grass, milkweed, buckbrush, smooth brome grass, bladder campion, wild licorice, gum weed and aster.	90	Main line—Width 20 ft. Ballast—gravel. Results—Very good when inspected Aug. 20, 1959. Appeared to provide excellent top kill. Ballast area free of vegetation. Few grasses survived. Smooth brome grass resprouted. Good top kill wild licorice but it resprouted from base of plant. Some milkweed plants survived and others severely injured.

[5]Monobor-chlorate No. 6—Anhydrous sodium metaborate 9.71%, sodium chlorate 17.00%.
[6]Fenac—2,3,6-Trichlorophenylacetic acid 1.5 lb acid equivalent per gal concentrate.
[7]TBA—2,3,6-Trichlorobenzoic acid 2 lb acid equivalent per gal.

Table 6—Results of Chemical Treatments Applied on Test Areas in Region 6

Type of Vegetation—Predominant species—Indiangrass, Johnson grass, big bluestem, little bluestem, sunflower, leavenworth eryngo, Bermuda grass, silver bluestem, ragweed and tall drop seed.

Other species—Purple nightshade, sideoats grama, aster, broomsedge, bluestem, sandbur, prairie threeawn, buffalo-bur, Carolina horsenettle, wooly verbena, daisy fleabane, cocklebur, Mexican fireweed, Russian thistle, prostrate spurge, Smilax spp. and lovegrass.

Type of Ballast—Gravel.

Date of Application—Test No.'s 1 through 4—Nov. 2, 1957; Test No. 5—Nov. 10, 1957; Test No. 6—Oct. 31, 1957.

Width of Treatment—24 ft.

Weather Data—Test No.'s 1 through 5, Cresson, Texas Station—Avg Max Temp: 1957—None recorded 1958—None recorded. 1959—None recorded. Precipitation: 1957—Oct.—5.00", Nov.—4.56", Dec.—2.98". Annual—1957—50.43". 1958—Jan.—2.16", Feb.—0.68", Mar.—2.55", Apr.—5.03", May—4.38", June—0.47", July—4.76", Aug.—1.38", Sept.—7.13", Oct.—1.87", Nov.— , Dec.— . Annual—1958—35.45". 1959—Jan.— , Feb.—0.63", Mar.—0.19", Apr.—3.31", May—2.45", June—4.94".

Test No. 6—Cleburne, Texas Station—Avg Max Temp: 1957—Oct.—63.2°, Nov.—53.4°, Dec.—52.9°. 1958—Jan.—47.0°, Feb.—45.6°, Mar.—51.1°, Apr.—63.5°, May—73.6°, June—94.3°, July—96.6°, Aug.—97.7°, Sept.—86.9°, Oct.—77.1°, Nov.—71.2°, Dec.—59.7°. 1959—Jan.—58.9°, Feb.—61.9°, Mar.—75.0°, Apr.—77.2°, May—85.2°, June—90.5°. Precipitation: 1957—Oct.—7.21", Nov.—5.80", Dec.—2.14". Annual—1957—50.95". Departure from average—16.63". 1958—Jan.—2.15", Feb.—1.29", Mar.—3.46", Apr.—5.87", May—3.18", June—2.35", July—3.13", Aug.—5.20", Sept.—6.71", Oct.—2.81", Nov.—2.91", Dec.—1.58". Annual—1958—39.92". Departure from average—5.60". 1959—Jan.—0.11", Feb.—3.34", Mar.—0.45", Apr.—3.41", May—3.40", June—7.70".

Date Inspected—May 13–14, 1958; Sept. 23–24, 1958 and June 20–23, 1959.

Test No.	*Treatment*	*Rate Applied Per Acre*	*Size of Test Area*	*Average Percent Reduction Vegetation*[1]						*Remarks*
				May 13–14, 1958		*Sept. 23–24, 1958*		*June 20–23, 1959*		
				O.G.[2]	*I.G.*[3]	*O.G.*	*I.G.*	*O.G.*	*I.G.*	
1	Sodium chlorate Sodium metaborate Telvar W[4]	56.22 lb 133.05 lb 4.31 lb	6.9 mi	32	42	21	0	16	0	Original infestation heavy outside gage, light inside gage. 1958 Results—This treatment appeared inadequate for controlling vegetation in this area under the high rainfall condition that occurred from time of application until inspected Sept. 1958. Annual species were killed and replaced by other annuals. Predominant species in Sept. 1958 were Johnson grass (some injury), upright spurge, sunflower, and prostrate spurge. Other species present were Indiangrass, big bluestem, horsenettle, Bermuda grass, silver bluestem and little bluestem. Annuals reinfested gage but their density rating was only 30 percent. 1959 Results—Predominant species that survived in June were Johnson grass, Indiangrass, sunflower and horsenettle. These infested area outside gage, the density being 64 percent. Annuals infested area inside gage. Density was 24 percent.

TABLE 6 (Continued)

Test No.	Treatment	Rate Applied Per Acre	Size of Test Area	Average Percent Reduction Vegetation[1]						Remarks
				May 13–14, 1958		Sept. 23–24, 1958		June 20–23, 1959		
				O.G.[2]	I.G.[3]	O.G.	I.G.	O.G.	I.G.	
2	Sodium chlorate Sodium metaborate Telvar W	57.90 lb 127.02 lb 6.65 lb	6.7 mi	28	29	20	0	1	0	Original infestation heavy outside gage, light inside gage. 1958 Results—Predominant species Sept. Johnson grass and Indiangrass. Resistant species were Johnson grass, Bermuda grass, Indiangrass, silver bluestem, little bluestem, and false golden aster. These infested area outside gage. Annuals that reinfested area were upright spurge, Russian thistle and ragweed. Horsenettle grew vigorously in May but its density had been greatly reduced in Sept. The area inside gage was reinfested primarily with annuals the density of which was 20 percent. Treatment inadequate. 1959 Results—Area outside gage heavily reinfested with Johnson grass and Bermuda grass, the density being 69 percent. Annuals and some Johnson grass infested area inside gage. Density inside gage only 21 percent.
3	Sodium chlorate Sodium metaborate Telvar W	55.98 lb 132.50 lb 8.58 lb	6.9 mi	33	37	29	0	20	0	Original infestation heavy outside gage, light inside gage. 1958 Results—Predominant species Sept. Johnson grass, Bermuda grass, annuals and Smilax spp. Resistant species were Johnson grass, silver bluestem, Indiangrass, Bermuda grass, Smilax spp. and purple nightshade. Horsenettle intermediately susceptible. Upright spurge reinfested area. Annuals reinfested inside gage, the density being 16 percent. 1959 Results—Predominant species that survived June 23 were Johnson grass, Indiangrass, Bermuda grass, sunflower and horsenettle. These primarily infested outside gage area. Density outside gage 57 percent. Some annuals infested area inside gage, the density being 17 percent.
4	Sodium chlorate Sodium metaborate Telvar W	57.90 lb 137.03 lb 11.09 lb	6.7 mi	31	42	37	20	7	0	Original infestation heavy outside gage, light inside gage. 1958 Results—Predominant species Sept. Johnson grass, silver bluestem, and Bermuda grass. Resistant species were Johnson grass, silver bluestem, Indiangrass, purple nightshade, Bermuda grass and little bluestem. Horsenettle intermediately susceptible. Upright spurge reinfested area. Growth of some perennials retarded. Some annuals eliminated but others reinfested area. 1959 Results—Predominant species that survived June 23 were Johnson grass, Indiangrass, horsenettle, sunflower, Bermuda grass, vine misquite and silver bluestem. These infested outside gage area. Density 63 percent. Some annuals reinfested inside gage area. Density inside gage area 12 percent.

TABLE 6 (Continued)

Test No.	Treatment	Rate Applied Per Acre	Size of Test Area	Average Percent Reduction Vegetation[1]						Remarks
				May 13–14, 1958		Sept. 23–24, 1958		June 20–23, 1959		
				O.G.[2]	I.G.[3]	O.G.	I.G.	O.G.	I.G.	
5	Sodium chlorate Sodium metaborate Telvar W	105.57 lb 249.88 lb 9.05 lb	4.8 mi	54	57	64	1	29	10	Original infestation heavy outside gage, light inside gage. 1958 Results—Fair control most vegetation. Johnson grass stand considerably reduced. Indiangrass, big bluestem, and little bluestem resistant. Some upright spurge, prostrate spurge, and three-seeded mercury reinfested area primarily inside gage. Vine-misquite and purple nightshade survived. 1959 Results—Predominant species that survived June 23 were Johnson grass, sunflower and three-seeded mercury. Evidence of some control or residual effects. Density outside gage 55 percent, inside gage 14 percent.
6	Chlorea Granular[5]	400 lb	0.6 mi	40	66	13	38	20	20	Original infestation heavy outside gage, light inside gage. 1958 Results—Predominant species Johnson grass and Bermuda grass. Resistant species Johnson grass, Bermuda grass and purple nightshade. Annual species eliminated but area heavily infested with Johnson grass and Bermuda grass. 1959 Results—Some of area disturbed by burning. Stand of Johnson grass decreased, its growth appeared retarded. Infestation primarily outside gage area. Resistant species Johnson grass, Bermuda grass, bull nettle and wild lettuce.

[1]Average percent reduction vegetation—Calculated from density ratings at time of application and at each inspection—May average of 4 individual ratings, Sept. average of 4 individual ratings and June one rating.
[2]O.G.—Outside gage.
[3]I.G.—Inside gage.
[4]Telvar W—3(p-chlorophenyl)-1,1-dimethylurea 80%.
[5]Chlorea Granular—Sodium chlorate 40%, sodium metaborate 54%, 3(p-chlorophenyl)-1,1-dimethylurea 2.4% (Technical).

TABLE 7—RESULTS OF CHEMICAL TREATMENTS APPLIED ON TEST AREAS IN REGION 7

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Nalco H-174 S[1]	157 lb	Dec. 12, 1957	Oakland Station — Avg Max Temp: 1958—Oct.—73.3°, Nov.—65.6°, Dec.-63.2°. 1959—Jan.—58.4°, Feb.—59.3°, Mar.—67.9°, Apr.—69.5°, May—68.2°. Precipitation — 1958: Oct.—0.22″, Nov.—0.09″, Dec.—1.49″, Precipitation—Annual—1958: 26.11″. Departure from avg. annual precipitation: 8.48″. 1959—Jan.—3.96″, Feb.—3.95″, Mar.—0.33″, Apr.—0.02″, May—Trace.	Salt grass (predominant), prostrate spurge, Hordeum spp.and annual spp.	70	Inspected May 19, 1959. Fire break area. Salt grass intermediately susceptible. Few plants of prostrate infested the area.
Nalco H-174 S	158 lb	Dec. 12, 1957	"	Salt grass (predominant), filaree, knotweed, wild lettuce, field bindweed, Hordeum spp. and annual spp.	65	Inspected May 19, 1959. Fire break area. Salt grass intermediately susceptible and reinfested area. Bindweed survived. Annual grasses, filaree, wild lettuce and knotweed emerged during spring 1959.
Nalco H-174 S	286 lb	Dec. 12, 1957	"	"	90	Inspected May 19, 1959. Fire break area. Some salt grass, bindweed and filaree reinfested area.
Nalco H-174 S	440 lb	Dec. 12, 1957	"	"	80	Inspected May 19, 1959. Fire break area. Alternate flooding during January and February, 1958. Salt grass only surviving specie.
Nalco H-174 S	500 lb	Dec. 12, 1957	"	"	98	Inspected May 19, 1959. Fire break area. Few sprigs salt grass survived.
Chlorea Granular No. 3[2]	200 lb	Dec. 12, 1958	"	Predominant species—yellow star thistle, Chinese lettuce, perennial morning glory, pigweed, perennial rye grass, wild mustard, annual grasses and wild licorice. Other species — salt grass, curled leaf dock, Turkey mullen, Heliotrope and cocklebur.	85	Inspected May 19, 1959. Branch line. Ballast—gravel and soil. Size of plot—16 ft wide, 0.2 mi long. Wild licorice resistant. Perennial morning glory and Chinese lettuce survived but showed slight chlorosis. Other species controlled.

TABLE 7 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Chlorea Granular No. 3	250 lb	Dec. 12, 1958	"	"	90	Inspected May 19, 1959. Branch line. Ballast—gravel and soil. Size of plot—16 ft wide, 0.2 mi long. Wild licorice resistant. Perennial morning glory intermediately susceptible.
Chlorea Granular No. 3	300 lb	Dec. 12, 1958	"	Predominant species—wild licorice (extremely heavy), yellow star thistle, Chinese lettuce, perennial morning glory, pigweed, perennial rye grass, wild mustard and annual grasses. Other species—salt grass, curled leaf dock, Turkey mullen, Heliotrope and cocklebur.	55	Inspected May 19, 1959. Branch line. Ballast—gravel and soil. Size of plot—16 ft wide, 0.2 mi long. Wild licorice resistant and infested 45 percent of area. Control 90 percent in area not infested with wild licorice.
Chlorea Granular No. 3	400 lb	Dec. 12, 1958	"	"	70	Inspected May 19, 1959. Branch line. Ballast—gravel and soil. Size of plot—16 ft wide, 0.2 mi long. Wild licorice resistant and heavily infested 30 percent of area. Some dock and perennial morning glory survived. Other species controlled.
Chlorea Granular No. 3	500 lb	Dec. 12, 1958	"	"	60	Inspected May 19, 1959. Branch line. Ballast—gravel and soil. Size of plot—16 ft wide, 0.2 mi long. Wild licorice resistant and heavily infested 40 percent of area. Some perennial morning glory intermediately susceptible.

[1]Nalco H-174 S—2-chloro-4,6-bis-(ethylamino)-s-triazine (Simazine 50W) 10.0% or 5.0% (Technical), sodium tetraborate 83%, inert (surfactants) 7.0%.
[2]Chlorea Granular No. 3—Sodium chlorate 40%, sodium metaborate 54%, 3-(p-chlorophenyl)-1,1-dimethylurea 2.4% (Technical).

TABLE 8—RESULTS OF BRUSH CONTROL TESTS REGIONS 2, 3, 4 AND 6

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
REGION 2						
Dybar[1]	25 lb	Feb. 5, 1959	Springfield, Illinois Station—1959—Avg Max Temp: Jan.—31.0°, Feb.—38.5°, Mar.—51.8°, Apr.—63.6°, May—76.8°, June—86.3°, July—86.4°, Aug.—87.3°, Sept.—79.4°. Precipitation: Annual—1958—30.56″. Departure from average (—6.09). 1959—Jan.—1.83″, Feb.—2.04″, Mar.—2.91″, Apr.—2.23″, May—3.15″, June—0.23″, July—3.64″, Aug.—5.39″, Sept.—6.47″.	Sumac, willow, elm, wild cherry, Osage orange, black locust, oak and cottonwood.	Injury	Size of area 49 ft wide, 1326 ft long (2 acres). Type of application—Cyclone seeders (broadcast). Inspected July 1 and Sept. 3, 1959. Results—All species showed light effects from chemical. Tops affected first. Typical urea symptoms—leaves chlorotic. Large trees on right-of-way line affected.
Dybar	50 lb	Feb. 5, 1959	"	"	Severely injured	Size of area 40 ft wide, 663 ft long (1 acre). Type of application—Cyclone seeders (broadcast). Inspected July 1 and Sept. 3, 1959. Results—Following species showed severe injury with some kill: Sumac, willow, elm and wild cherry. Following species showed slight effects from chemical: Osage orange, black locust, oak, and cottonwood.
Nalco H-175D[2]	Basal 37.5 gal sol.	Feb. 5, 1959	"	"	100	Size of area 40 ft wide, 273 ft long (0.4 acre). Type of application—knapsack sprayer. (basal). Inspected July 1 and Sept. 3, 1959. Results—Complete top kill all species. No apparent resprouting at this inspection.
Dybar	33 lb	Feb. 3, 1959	Fairfield Radio WFIW, Illinois Station—Avg Max Temp—1959—Jan.—39.6°, Feb.—46.5°, Mar.—57.7°, Apr.—68.6°, May—79.4°, June—85.9°, July—89.0°, Aug.—88.1°, Sept.—82.6°. Precipitation: Annual—1958—41.46″. 1959—Jan.—3.58″, Feb.—3.20″, Mar.—2.36″, Apr.—2.19″, May—7.79″, June—0.70″, July—3.54″, Aug.—6.90″, Sept.—5.74″.	Elm, willow, sycamore, red oak, bur oak, white oak, black oak, cottonwood, river birch, wild cherry, sumac, sassafras, persimmon, hickory, red bud, boxelder, walnut and Spanish mulberry.	Slight injury	Size of area 50 ft wide, 2652 ft long (1.7 acres). Type of treatment—Cyclone seeders (broadcast). Inspected June 30 and Sept. 3, 1959. Results—Following species showed considerable injury from chemical: elm, oak and wild cherry. Leaves chlorotic. All species showed signs of slight chlorosis.

TABLE 8 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Dybar	65 lb	Feb. 3, 1959	"	"	Slight injury	Size of area 50 ft wide, 1326 ft long (3.04 acres). Type of application—Cyclone seeders (broadcast). Inspected June 30 and Sept. 3, 1959. Results—Following species showed considerable injury from chemical: elm, willow, oak, wild cherry, hickory, and walnut. All species showed signs of slight chlorosis.
Dybar	16 lb	June 19, 1958	Chicago, Illinois Airport Station—Avg Max Temp—1958—Jan.—31.5°, Feb.—26.7°, Mar.—41.0°, Apr.—60.4°, May—73.1°, June—74.1°, July—81.5°, Aug.—83.2°, Sept.—75.5°, Oct.—67.4°, Nov.—50.8°, Dec.—29.5°. 1959—Jan.—26.6°, Feb.—33.5°, Mar.—45.2°, Apr.—58.2°, May—75.9°, June—82.6°, July—84.5°, Aug.—87.3°, Sept.—78.3° Precipitation: 1958 — Jan.—1.12″, Feb.—0.33″, Mar.—0.33″, Apr.—1.64″, May—3.12″, June—6.43″, July—4.74″, Aug.—2.51″, Sept.—1.86″, Oct.—2.12″, Nov.—1.58″, Dec.—0.57″. Annual 1958—26.35″. Departure from Average (—6.37″). 1959—Jan.—2.13″, Feb.—2.39″, Mar.—3.91″, Apr.—4.00″, May—3.87″, June—5.94″, July—4.77″, Aug.—1.63″, Sept.—2.17″.	Willow.	15	Inspected Aug. 12, 1958 and Oct. 29, 1959. Type of treatment—Cyclone seeders (broadcast). 1958 Results—5 percent kill. Leaves chlorotic. 1959 Results—Some plants showed slight injury.
Dybar	32 lb	June 19, 1958	"	"	30	Inspected Aug. 12, 1958 and Oct. 29, 1959. Type of treatment—Cyclone seeders (broadcast). 1958 Results—5 percent kill. Leaves chlorotic. 1959 Results—30 percent kill. Leaves injured. Some defoliation earlier in season.

TABLE 8 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Dybar	64 lb	June 19, 1958	"	"	70	Inspected Aug. 12, 1958 and Oct. 29, 1959. Type of treatment—Cyclone seeders (broadcast). 1958 Results—20 percent kill. Leaves seriously injured and chlorotic. 1959 Results—70 percent kill. Evidence of defoliation earlier in season. Leaves showed signs of severe injury.
TBA Granules[3]	16 lb	June 25, 1958	"	"	30	Inspected Aug. 12, 1958 and Oct. 29, 1959. Type of treatment—Cyclone seeders (broadcast). 1958 Results—10 percent kill. Leaves chlorotic. 1959 Results—30 percent kill. Leaves showed signs of injury.
TBA Granules	48 lb	June 25, 1958	"	"	50	Inspected Aug. 12, 1958 and Oct. 29, 1959. Type of treatment—Cyclone seeders (broadcast). 1958 Results—50 percent kill. Plants severely injured.
TBA Granules	64 lb	June 25, 1958	"	"	100	Inspected Aug. 12, 1958 and Oct. 29, 1959. 1958 Results—90 percent kill. 1959 Results—100 percent kill.
REGION 3						
Technical T O.S.[4]	9.5 lb in 144 gal diesel oil	Mar. 20, 1959	Memphis, Tennessee Airport Station—Avg Max Temp—1959—Jan.—48.9°, Feb.—53.8°, Mar.—62.9°, Apr.—71.9°, May—83.9°, June—86.8°, July—88.9°, Aug.—90.2°, Sept.—85.5°. Precipitation: Annual—1958—53.93″. Departure from mean (4.51″). 1959—Jan.—4.34″, Feb.—5.21″, Mar.—3.56″, Apr.—3.73″, May—1.85″, June—4.82″, July—8.84″, Aug.—4.56″, Sept.—2.73″.	Predominant — Elderberry, (beginning to bud, some primary leaves), sumac, sassafras, sycamore, sweet gum, cottonwood and willow. Other species — Poplar, white oak, wild cherry, scrub oak (blackjack oak), elm, trumpet vine and honeysuckle.	90	Size of area—30 ft wide, 9 mi long (spot treatment equiv. to 3.53 mi continuously or 32.62 acres). Type of treatment—On track equipment—dormant stem or cane broadcast. Inspected July 24, 1959. Results—Initial top kill 100 percent. Approximately 10 percent resprouting from roots and/or base of plant. Species that resprouted were sumac (root sprouting), sassafras (root sprouting), elderberry and sycamore. Note: 99 percent kill of sassafras.

TABLE 8 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Dybar	57 lb	Feb. 11, 1959	Weir, Mississippi Station—Avg Max Temp—1959—Jan.— , Feb.—62.4°, Mar.—68.0°, Apr. 75.9°, May—86.0°, June—88.2°, July—91.4°, Aug.—92.3°, Sept.—86.8°. Precipitation: Annual—1958—52.11″. Departure from mean (0.10″), 1959—Jan.—3.45″, Feb.—5.09″, Mar.—6.87″, Apr.—6.88″, May—4.34″, June—2.24″, July—7.42″, Aug.—3.16″, Sept.—5.11″.	Sumac, maple, sweet gum, sassafras, tulip poplar, American elm, persimmon, ash, wild cherry, pin oak, winged elm, and pine.	Slight injury	Size of area—44 ft wide, 850 ft long (0.88 acre). Type of treatment—Cyclone seeders—broadcast. Inspected July 23, 1959. Results—All species showed signs of slight injury—leaves slightly chlorotic. Some suppression of growth. Note: Large oak tree killed off right-of-way.
Dybar	108 lb	Feb. 11, 1959	"	"	Injury	Size of area—44 ft wide, 364 ft long (0.37 acre). Type of treatment—Cyclone seeders—broadcast. Inspected July 23, 1959. Results—All species injured. Leaves chlorotic. Growth suppressed. Some sumac killed, sweet gum severely injured. Large pin oaks off right-of-way severely injured.
Dybar	1 tablespoon per stem—equiv. to 100 lb	Feb. 11, 1959	"		75	Size of area—44 ft wide, 66 ft long (0.066 acre). Type of treatment—Basal or stem. Inspected July 23, 1959. Results—All species dead or showed signs of severe injury. Sweet gum 80 percent kill. Poplar slight injury—some chlorosis. Pine severely injured.
Nalco H-175D	Basal	Feb. 11, 1959		"	65	Size of area—44 ft wide, 50 ft long (0.05 acre). Type of treatment—Knapsack sprayer—basal. Inspected July 23, 1959. Results—Brush extremely dense in this area. Most species not killed were injured. Growth suppressed. Ash and persimmon appeared to be resistant. Some poplar survived. Sumac resprouted from roots.

TABLE 8 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Dybar	1 tablespoon per stem—equiv. to 40 lb	Feb. 10, 1959	Monroe, Louisiana Station (Rayville, La.)—Avg Max Temp—1959—Jan.—51.1°, Feb.—59.9°, Mar.—68.5°, Apr.—75.0°, May—85.8°, June—87.9°, July—71.5°, Aug.—92.7, Sept.—86.8°. Precipitation: Annual—1958—57.26″. 1959—Jan.—1.91″, Feb.—2.70″, Mar.—3.82″, Apr.—5.55″, May—3.73″, June—4.38″, July—6.12″, Aug.—3.07″, Sept.—3.00″.	Elm, honey locust, sumac, elderberry, sweet gum, mulberry, persimmon and boxelder.	90	Size of area—48 ft wide, 1131 ft long (1.25 acre). Type of treatment—Basal or stem. Area sprayed with Ammate during 1957 and 1958 season. Inspected July 22, 1959. Results—Good control. All species that had leaves showed signs of injury—leaves chlorotic and growth retarded.
Dybar	2 tablespoons per stem—equiv. to 64 lb	Feb. 10, 1959	"	Elm, sumac, honey locust, boxelder, elderberry and skunkbrush.	98	Size of area—48 ft wide, 702 ft long (0.78 acre). Type of treatment—Basal or stem. Area sprayed with Ammate during 1958 season. Inspected July 22, 1959. Results—Very good control. Only one elm and 2 boxelder plants that resprouted. Skunkbrush injured. Leaves slightly chlorotic.
REGION 4						
Dybar	50 lb	Feb. 9, 1959	Yazoo City Mississippi Station (Harriston, Miss.) — Avg Max Temp—1959—Jan.—55.9°, Feb.—60.3°, Mar.—67.4°, Apr.—75.4°, May—86.8°, June—88.9°, July—92.4°, Aug.—93.4°, Sept.—87.7°. Precipitation: Annual—1958—50.03″. Departure from mean—(0.20″). 1959—Jan.—2.88″, Feb.—4.77″, Mar.—5.76″, Apr.—6.17″, May—5.72″, June—5.36″, July—6.08″, Aug.—2.34″, Sept.—4.33″.	Sumac, sweet gum, honey locust, oak, sassafras, elderberry, willow, cottonwood, persimmon, peach, birch and trumpet vine.	Slight injury	Size of area—30 ft wide, 1161 ft long (0.8 acre). Type of treatment—Cyclone seeders (broadcast). Inspected July 21, 1959. Results—All species showed symptoms of slight injury. Leaves chlorotic.
Dybar	125 lb	Feb. 9, 1959	"	"	70	Size of area—30 ft wide, 550 ft long (0.38 acre). Type of treatment—Cyclone seeders (broadcast). Inspected July 21, 1959. Results—All brush except sassafras defoliated or showed definite chlorosis. Large trees gum and willow dead. Some sumac dead, other plants severely injured. Elderberry, locust, peach and persimmon severely injured.

TABLE 8 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Dybar	1 tablespoon per stem—equiv. to 100 lb	Feb. 9, 1959	"	"	90	Size of area—41 ft wide, 125 ft long (.094 acre). Type of treatment—Basal or stem. Inspected July 21, 1959. Results—Good kill. A few terminal leaves on some sumac but appeared to be chlorotic. Locust dead or dying. Cottonwood seedling survived. Trumpet vine chlorotic.
Nalco H-175-D	70 gal sol.	Feb. 9, 1959	"	"	85	Size of area—41 ft wide, 340 ft long (0.3 acre). Type of treatment—Knapsack sprayers—Basal. Inspected July 21, 1959. Results—Top kill all species 100 percent. Approximately 15 percent regrowth. Species that resprouted were sumac and sassafras. These resprouted from roots.
REGION 6						
Dybar	36 lb	May 22, 1958	College Station, Texas—Station—Avg Max Temp—1958—Jan.—59.3°, Feb.—57.8°, Mar.—65.8°, Apr.—78.5°, May—88.1°, June—95.9°, July—98.1°, Aug.—97.9°, Sept.—89.0°, Oct.—77.3°, Nov.—71.9°, Dec.—59.4°. 1959—Jan.—59.7°, Feb.—63.1°, Mar.—72.3°, Apr.—75.0°, May—87.0°, June—91.9°, July—94.6°, Aug.—93.0°, Sept.—90.9°. Precipitation: Annual—1957—56.10″. 1958—Jan.—3.05″, Feb.—2.72″, Mar.—1.58″, Apr.—4.17″, May—1.99″, June—2.40″, July—7.06″, Aug.—1.66″, Sept.—12.13″, Oct.—2.90″, Nov.—2.23″, Dec.—1.48″. Annual—1958—43.37″. 1959—Jan.—0.34″, Feb.—4.46″, Mar.—0.66″, Apr.—6.37″, May—5.24″, June—3.46″, July—2.89″, Aug.—6.29″, Sept.—2.27″.	Post oak, blackjack oak, chittamwood, grape, dewberry, trumpet vine, willow yappon and dogwood.	15	Size of area—60 ft wide, 363 ft long (0.5 acre). Aerial application. Inspected Sept. 25, 1958 and June 19, 1959. Results—1958—15 percent kill. Leaves brown around edge. 1959—Results similar to 1958 control. Some leaves chlorotic. Grape, willow and yappon survived.

TABLE 8 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Dybar	48 lb	May 22, 1958	"	"	65	Size of area—60 ft wide, 363 ft long (0.5 acre). Aerial application. Inspected Sept. 25, 1958 and June 19, 1959. Results 1958—55 percent control. Some defoliation. All species injured and appeared to be dying. 1959—Fair kill oak. Some oak plants survived but were severely injured. Dogwood survived but some plants had been defoliated.
TBA Granules	26 lb	May 22, 1958	"	"	None	Size of area—60 ft wide, 363 ft long (0.5 acre). Aerial application. Inspected Sept. 25, 1958 and June 19, 1959. Results 1958—Brush injured. 1959—Brush cut, resprouted with no evidence of control.
TBA Granules	40 lb	May 22, 1958	"	"	30	Size of area—60 ft wide, 363 ft long (0.5 acre). Aerial application. Inspected Sept. 25, 1958 and June 19, 1959. Results—1958—30 percent control. Some defoliation. Leaves brown indicated signs of injury. 1959—Brush cut. Evidence of some kill. Oak appeared to be resprouting.
TBA Dybar	13 lb 24 lb	May 22, 1958	"	"	30	Size of area—60 ft wide, 363 ft long (0.5 acre). Aerial application. Inspected Sept. 25, 1958 and June 19, 1959. Results—1958—Approximately 40 percent control. Grape vines killed. Oak leaves injured showing considerable browning. 1959—Vines killed. Some injury of bursh. Weed growth suppressed.

TABLE 8 (Continued)

Treatment	*Rate Applied Per Acre*	*Date Applied*	*Weather Data*	*Type of Vegetation*	*Percent Control*	*Remarks*
Nalco H-174 Granules[5] . .	80 lb	May 22, 1958	"	"	Injured	Size of area—60 ft wide, 453 ft long (0.62 acre). Aerial application. Inspected Sept. 25, 1958 and June 19, 1959. Results—1958—Approximately 30 percent control. Leaves brown around edge. 1959—Evidence of slight injury on brush. Suppressed weed and grass growth.

[1]Dybar—3-phenyl-1,1-dimethylurea—25% active ingredient.
[2]Nalco H-175-D—2,4,5-trichlorophenoxyacetic acid, propylene glycol butyl ether esters 30%, acid equiv. 19.8% 2,4,5-trichlorophenoxyacetic acid or 1.6 lb 2,4,5-T per gal, aromatic petroleum oil including dye 70%. Dilution 1:9.
[3]TBA Granules—Trichlorobenzoic acid 25%.
[4]Technical T O.S.—2,4,5-Trichlorophenoxyacetic acid (oil soluble) 6 lb acid equiv. per gal.
[5]Nalco H-174-Granules—Sodium metaborate 83%, 3-(p-chlorophenyl)-1,1-dimethylurea 8%, inert ingredient (surfactants) 9%.

Table 9—Results of Brush Control Tests Region 2 and 3

Test 1—Region 2
Date applied—June 25, 1959. Date Inspected—October 6, 1959.
Method of application—Reps 1 and 2 air gun, Rep 3 hand.
Type of Vegetation—Predominant species—Elm, sumac, honey locust, red bud, red oak, ash and wild cherry. Other species (including underbrush)—Sycamore, persimmon, mulberry, dogwood, chestnut oak, black oak, pin oak, elderberry, boxelder, hickory, cottonwood, cedar, soft maple, buckbrush, wild grape, Virginia creeper, blackberry, dewberry, wild rose trumpetvine, poison ivy, vine (grape spp.) raspberry, Smilax spp., vine (unidentified) paper birch, walnut and wild plum.
Condition of Brush—Density 100 percent, height 15 to 20 ft except in plots denoted by an asterisk (*) where brush was more recently cut the height of which was 6 to 8 ft.
Weather Data—Osceola, Missouri Station—Avg Max Temp—1959—Jan.40.6°, Feb.—47.8°, Mar.—61.5°, Apr.—70.6°, May—80.2°, June—86.5°, July—86.9°, Aug.—92.3°, Sept.—84.6°.
Precipitation—Annual—1958—40.01″. 1959—Jan.—1.86″, Feb.—2.59″, Mar.—2.51″, Apr.—2.48″, May—3.72″, June—2.16″, July—6.84″, Aug.—1.99″, Sept.—6.07″.
Soil type—Red clay with some rock. Rolling cut and fill section.
Size of Plots—40 ft wide, 272 ft long (0.25 acre).

Test 2—Region 3
Date Applied—June 18, 1959. Date Inspected—October 8, 1959.
Method of Application—Hand
Type of Vegetation—Predominant species—Sweet gum, sumac, persimmon, red haw, sassafras and pine. Other species (including underbrush)—Winged elm, American elm, willow oak, red oak, willow, wild plum, live oak, sycamore, ash, black locust, hickory, hazelnut, elderberry, cedar, Columbine, trumpet vine, skunkbrush, blackberry, dewberry, grape, Smilax spp., sensitive rose, buttonbush, honeysuckle, blueberry and wild rose.
Condition of Brush—Density 90 percent and height 10 to 25 ft except in plots denoted by an asterisk (*). In these plots density was approximately 60 to 70 percent and height was 6 to 10 ft.
Weather Data—Ashdown, Arkansas Station—Avg Max Temp—1959—Jan.—55.8°, Feb.—58.8°, Mar.—69.8°, Apr.—75.1°, May—85.6°, June— , July— , Aug.—92.7°, Sept.—87.1°.
Precipitation—Annual—1958—55.86″. 1959—Jan.—1.17″, Feb.—5.16″, Mar.—3.69″, Apr.—2.86″, May—3.98″, June—4.55″, July—3.38″, Aug.—1.10″, Sept.—3.98″.
Soil Type—Clay loam. Slightly rolling to level terrain.
Size of Plots—40 ft wide, 272 ft long (0.25 acres).

Treatment	*Rate Applied Per Acre*	*Percent Control*								*Remarks*
		Test 1—October 6, 1959				*Test 2—October 8, 1959*				
		Rep 1	*Rep 2*	*Rep 3*	*Avg.*	*Rep 1*	*Rep 2*	*Rep 3*	*Avg.*	
Dybar[1]	40 lb	30	40	30	33	50	70	50	57	Test 1—Rep 2 received heavy application equiv. to 51 lb per acre. Method of application—Reps 1 and 2 air gun, Rep 3 hand. Predominant species—Reps 1 and 2 elm, sumac and honey locust; Rep 3 elm and redbud. Average percent kill of various species is as follows: elm 61 percent, sumac 76 percent (Rep 2 100 percent); honey locust 55 percent (Rep 3 severely injured), ash 75 percent, rep 3 only with slight injury Reps 1 and 2. Buckbrush 40 percent Rep 3, wild grape 50 percent Rep 1, walnut 75 percent. Following species slightly injured—leaves chlorotic: Red oak (Reps 1, 2 and 3), wild cherry (Reps 1 and 2), red bud (Reps 1 and 3) leaves browning, chestnut oak (Rep 2), and paper birch (Rep 1). Resistant species were: persimmon, mulberry (Reps 1 and 3), dogwood (Rep 3), wild plum (Rep 3), Virginia creeper (Reps 1, 2 and 3), blackberry (Rep 3), wild rose (Rep 3), poison ivy (Rep 3), raspberry (Rep 1) and Smilax spp. (Rep 2).

TABLE 9 (Continued)

Treatment	Rate Applied Per Acre	Percent Control								Remarks
		Test 1—October 6, 1959				Test 2—October 8, 1959				
		Rep 1	Rep 2	Rep 3	Avg.	Rep 1	Rep 2	Rep 3	Avg.	
Dybar[1]	40 lb	30	40	30	33	50	70	50	57	Test 2—Method of application—Hand. Predominant species—Rep 1 sumac and sassafras, Rep 2 persimmon, Rep 3 sumac and red haw. Average percent control of various species is as follows: Sumac (Reps 1, 2 and 3), 75 percent, sassafras (Rep 1) 70 percent, persimmon (Reps 2 and 3) 80 percent, red haw (Reps 2 and 3) 60 percent (severe injury—some defoliation), sweet gum (Reps 1 and 2) 65 percent, winged elm (Rep 1) 40 percent, American elm (Rep 1) 50 percent, trumpet vine (Rep 2) 40 percent (slight chlorosis Rep 1), blackberry (Reps 1, 2 and 3) 80 percent. Following species slightly injured—leaves chlorotic: willow oak (Rep 1), red oak (Reps 2 and 3) wild plum (Rep 1), live oak (Reps 2 and 3), hickory (Rep 2), hazel nut (Rep 2), elderberry (Rep 2), Columbine (Rep 2) and dewberry (Reps 2 and 3). Sensitive rose (Rep 2) and blueberry (Rep 3) killed.
Dybar	60 lb	60	75	55	63	55	75	50	60	Test 1—Rep 2 received heavy application equiv. to 70 lb per acre. Method of application—Reps 1 and 2 air gun, Rep 3 hand. Predominant species—Rep 1—elm and honey locust, Reps 2 and 3—elm. Average percent control of various species is as follows: elm (Reps 1, 2 and 3) 68 percent (appeared to have been defoliated during summer), honey locust (Reps 1, 2 and 3) 80 percent, sumac (Reps 1, 2 and 3) 80 percent, red oak, 75 percent Rep 1 (slight injury Rep 3), wild cherry (Reps 1 and 2) 50 percent, persimmon 50 percent Rep 1 (slight injury Reps 2 and 3), and buckbrush (Reps 1 and 2) 85 percent. Following species slightly injured: ash (Reps 2 and 3), sycamore (Reps 1 and 3), chestnut oak (Rep 2) and pin oak (Reps 1 and 3). Smilax spp. resistant, elderberry (Rep 1), wild grape (Reps 1 and 2), Virginia creeper (Reps 1, 2 and 3), dewberry (Reps 1, 2 and 3) and vine grape spp. (Rep 1) killed. Test 2—Method of application—Hand. Predominant species—Rep 1 sweet gum and sumac, Rep 2 sweet gum, Rep 3 red haw. Average percent control of various species is as follows: sweet gum (Reps 1 and 2) 75 percent, sumac (Reps 1 and 3) 80 percent, winged elm (Rep 3) 60 percent, American elm 85 percent Rep 1 (severely injured—edge of plot Rep 2), persimmon (Reps 2 and 3) 80 percent, sassafras (Rep 2) 50 percent, red oak (Reps 2 and 3) 63 percent, wild plum (Rep 1), 75 percent, live oak (Reps 2 and 3) 40 percent, blackberry (Reps 1, 2 and 3) 95 percent and buttonbush (Rep 2) 70 percent. Following species were slightly injured with leaves chlorotic: red haw (Rep 3), trumpet vine (Reps 1 and 2), skunkbrush (Reps 1, 2 and 3), dewberry (Reps 1, 2 and 3), grape (slight chlorosis Rep 1, killed Rep 2), Smilax spp. (Reps 1, 2 and 3) and wild rose (Rep 3). No effects on pine (edge of plot Rep 2). Sensitive rose (Reps 1 and 2) killed.

TABLE 9 (Continued)

Treatment	Rate Applied Per Acre	Percent Control								Remarks
		Test 1—October 6, 1959				Test 2—October 8, 1959				
		Rep 1	Rep 2	Rep 3	Avg.	Rep 1	Rep 2	Rep 3	Avg.	
Dybar	80 lb	50	80	60	63	75	80	85	80	Test 1—Rep 1 received heavy application equiv. to 93.45 lb per acre. Method of application—Reps 1 and 2 air gun, Rep 3 hand. Predominant species—Rep 1 elm and honey locust. Reps 2 and 3 elm and sumac. Average percent control of various species is as follows: elm (Reps 1, 2 and 3) 77 percent, sumac (Reps 1, 2 and 3) 78 percent, honey locust (Reps 1 and 2) 82 percent, red bud (Rep 1) 50 percent, walnut (Rep 2) 65 percent, poison ivy (Rep 2) 60 percent. Following species were slightly injured—leaves chlorotic: red oak (Reps 1, 2 and 3), ash (Reps 2 and 3), wild cherry (Reps 1 and 3), sycamore (Reps 1 and 2), dogwood (Reps 1 and 2), pin oak (Rep 1), boxelder (Rep 1), paper birch (Rep 1), wild rose (Rep 2), trumpet vine (Rep 2), cedar (no effects Rep 1, slight browning Rep 3). No effects on persimmon (Reps 2 and 3) and mulberry (Rep 1). Following species were killed: cottonwood, (Rep 2), buckbrush (Rep 3), wild grape (Reps 2 and 3), Virginia creeper (Reps 1 and 2), blackberry (Rep 2), dewberry (Rep 3) and raspberry (Rep 1). Test 2—Method of application—hand. Predominant species—Rep 1 sweet gum and pine, Rep 2 persimmon, Rep 3 red haw. Average percent control of various species is as follows: sweet gum (Reps 2 and 3) 75 percent, pine 80 percent, persimmon (Reps 1, 2 and 3) 82 percent, red haw (slight injury Rep 2, 50 percent Rep 3), sumac (Reps 1, 2 and 3) 80 percent, winged elm (Reps 2 and 3) 82 percent, American elm (Reps 1 and 2) 92 percent, black locust (Rep 3) 60 percent, Smilax spp. (Rep 3) 70 percent and ash (Rep 1) 75 percent. Following species slightly injured: red oak (Reps 1, 2 and 3—browning of leaves), live oak (Rep 2), trumpet vine (Rep 1), skunkbrush (Reps 2 and 3), dewberry (Reps 2 and 3) and sensitive rose (Rep 2). Blackberry (Reps 1, 2 and 3) killed.
Benzabor[2]	100 lb	80	75	35	63	75	40	60	58	Test 1—Rep 1 received heavy application equiv. to 112 lb per acre. Method of application—Reps 1 and 2 air gun, Rep 3 hand. Predominant species Rep 1 elm and honey locust, Rep 2 elm and sumac, Rep 3 red bud. Average percent control of various species is as follows: elm (Reps 1, 2 and 3) 91 percent, sumac (Reps 1, 2 and 3) 100 percent, honey locust (Reps 1, 2 and 3) 100 percent, red bud (Reps 1 and 3) slight injury—some defoliation Rep 1, sycamore (Reps 2 and 3) 60 percent Rep 2, slight injury Rep 3, persimmon (Rep 2) 50 percent and boxelder (Rep 2) 45 percent. Following species slightly injured—leaves chlorotic: red oak (Reps 1 and 3), ash (Reps 1, 2 and 3), wild cherry (Rep 2), chestnut oak (Rep 2), hickory (Reps 1 and 3), wild grape (Reps 2 and 3), Virginia creeper (Reps 2 and 3), paper birch (Rep 2), walnut (Rep 2) and wild plum (Rep 2). Dogwood, cedar (one plant brown) and Smilax spp. resistant. Blackberry (Reps 1 and 2), poison ivy (Rep 2) and vine (unidentified—Rep 2) killed.

TABLE 9 (Continued)

Treatment	Rate Applied Per Acre	Percent Control								Remarks
		Test 1—October 6, 1959				Test 2—October 8, 1959				
		Rep 1	Rep 2	Rep 3	Avg.	Rep 1	Rep 2	Rep 3	Avg.	
Benzabor[2]	100 lb	80	75	35	63	75	40	60	58	Test 2—Method of application—hand. Predomiant species—Rep 1 pine, Rep 2 sweet gum, and Rep 3 red haw. Average percent control of various species is as follows: sweet gum (Reps 1 and 2) severely injured, leaves browning, pine (Rep 1) 80 percent, red haw (Rep 3) 30 percent, sumac (Rep 2) 100 percent, winged elm (Rep 3) 100 percent, persimmon (Reps 1 and 3) 95 percent, red oak (Reps 1, 2 and 3) 40 percent Rep 1, slight browning of leaves Reps 2 and 3, blackberry (Reps 1, 2 and 3) 90 percent, and wild plum 70 percent. Following species slightly injured: American elm (Rep 2), willow oak (Rep 1), willow (Rep 1), live oak (Reps 2 and 3– brown spots on leaves), hazelnut (Rep 3), elderberry (Rep 2), Columbine (Rep 2), trumpet vine (Rep 2), skunkbrush (Reps 2 and 3), dewberry (Reps 2 and 3), grape (Rep 2) and Smilax spp. (Rep 3—severely injured). Sensitive rose killed.
Benzabor	200 lb	90	90	90	90	65	75	75	71	Test 1—Method of application—Reps 1 and 2 air gum, Rep 3 hand. Predominant species—Reps 1 and 2, elm and honey locust, Rep 3 elm and sumac. Average percent control of various species is as follows: elm (Reps 1, 2 and 3) 100 percent, sumac (Reps 1, 2 and 3) 100 percent, honey locust (Reps 1, 2 and 3) 98 percent, sycamore (Reps 1 and 3) 75 percent, dogwood (Reps 1 and 3) 100 percent, elderberry (Rep 3) 100 percent, boxelder (Rep 1) 80 percent and vine (grape spp.—Rep 2) 95 percent. Following species slightly injured: red oak (Reps 1, 2 and 3), ash (Reps 1, 2 and 3), wild cherry (Reps 1 and 3) severely injured—some defoliation, red bud (Reps 2 and 3), chestnut oak (Reps 2 and 3), hickory (Rep 3) severely injured, soft maple (Rep 3) and paper birch (Reps 1, 2 and 3) severely injured—some defoliation. Underbrush killed. These species were killed: buckbrush (Reps 1 and 2), wild grape (Reps 1, 2 and 3), Virginia creeper (Reps 1 and 2), blackberry (Reps 1 and 2), wild rose (Reps 1 and 2), trumpet vine (Rep 3) top kill– some resprouting and poison ivy (Rep 3). Test 2—Method of application—hand. Predominant species—Reps 1 and 2—sweet gum, Rep 3 red haw. Average percent control of various species is as follows: sweet gum—browning of leaves—slight defoliation, sumac (Reps 1, 2 and 3) 100 percent, winged elm (Rep 3) 100 percent, American elm (Reps 1 and 2) 100 percent, persimmon (Reps 1 and 3) 100 percent, sassafras (Rep 1) 75 percent, red haw (Rep 3) 40 percent. Following species slightly injured: pine (Rep 1), red oak (Reps 1, 2 and 3) slight browning and distortion of leaves, willow (Rep 2), live oak (Rep 3), sycamore (Rep 1), hickory (Reps 2 and 3), cedar (Reps 1 and 2) severe injury and Smilax spp. (Reps 2 and 3) some defoliation. Underbrush killed—skunkbrush (Reps 1 and 3), blackberry (Rep 3), wild rose (Rep 3) and trumpet vine (Rep 2) 100 percent top kill.

TABLE 9 (Continued)

Treatment	Rate Applied Per Acre	Percent Control								Remarks
		Test 1—October 6, 1959				Test 2—October 8, 1959				
		Rep 1	Rep 2	Rep 3	Avg.	Rep 1	Rep 2	Rep 3	Avg.	
XPI-63[3]	200 lb	70	75	50	65	------	------	------	------	Test 1 only—Method of application—Reps 1 and 2 air gun, Rep 3 hand. Predominant species—Rep 1 and 2—elm and honey locust, Rep 3—elm. Average percent control of various species is as follows: elm (Reps 1, 2 and 3) 71 percent, sumac (Reps 1, 2 and 3) 100 percent, honey locust (Reps 1 and 2) 80 percent, dogwood (Rep 2) 75 percent, and black locust (Rep 3) 40 percent. Following species slightly injured: wild cherry (Reps 1 and 3)—some defoliation, sycamore (Reps 1 and 3) leaves turning brown, red oak (Reps 1 and 3) severely injured—leaves brown, chestnut oak (Rep 2) and pin oak (Reps 1, 2 and 3). Underbrush killed—buckbrush (Reps 1 and 3) 80 percent kill, wild grape (Rep 3), Virginia creeper (Rep 3), blackberry (Reps 1 and 3), dewberry (Rep 3 and wild rose (Rep 2) 80 percent kill.

[1]Dybar—3-phenyl-1,1-dimethylurea 25%.
[2]Benzabor—Disodium tetraborate pentahydrate 54.5%, disodium tetraborate decahydrate 35.5%, trichlorobenzoic acid 8%, boron trioxide equiv. 39%, inert ingredient 2%.
[3]XPI-63—Experimental material.

TABLE 10—COST OF MATERIALS USED FOR VEGETATION CONTROL DURING 1959 (FOB PLANT)

Chemical	*Composition*	*Recommended Rate Per Acre*	*Dilution of Concentration Chemical:Water*	*Cost Per Lb or Gal*	*Cost Per Acre*
1. Agronyl R	Aromatic oil	80–120 gal	None	$0.0875	$ 7.00–10.50
2. Atlacide Liquid	Calcium chlorate 25%, sodium chloride 14%, inert ingredient 61%	50–80 gal	1:3	$0.49	$ 24.50–39.20
3. Atlacide-2,4-D S.P.	Sodium chlorate 58%, 2,4-Dichlorophenoxyacetic acid .1% (acid equiv.)	600–800 lb	Dry	$0.1025	$ 61.50–82.00
4. Atlas A	Arsenic trioxide (As_2O_3) 4 lb/gal conc.	20–100 gal	1:7 1:9	$0.345	$ 6.90–34.50
5. Atlas D	Arsenic trioxide (As_2O_3) 3.77 lb/gal conc+animal repellent	20–100 gal	1:6 1:9	$0.495	$ 9.90–49.50
6. Atrazine 80W	2-chloro-4-ethylamino-6-isopropylamino-s-triazine 80%	18¾ lb	None	$3.25	$ 40.63–60.94
7. Baron	2-(2,4,5-trichlorophenoxy) ethyl 2,2 dichloropropionate, 4 lb per gal	5–40 gal conc	1:8	$4.28	$ 21.40–171.20
8. Benzabor	Disodium tetraborate pentahydrate 54.5%, disodium tetraborate decahydrate 35.5%, boron trioxide equiv. 39%, trichlorobenzoic acid 8%	80–240 lb	Dry	$0.375	$ 30.00–90.00
9. Borascu 28	B_2O_3 Content 28%	2500–6090 lb	Dry	$0.011	$ 27.50–66.99
10. Calabor No. 33 Weed Killer	Ammate X 0.25 lb/gal, dalapon 0.3 lb per gal	90–100 gal conc	1:1	$0.382	$ 34.38–38.20
11. Calabor No. 42 Weed Killer	Sodium chlorate 1.8 lb/gal, sodium metaborate 1.15 lb/gal and surfactants	60–66 gal conc	1:1 to 1:3	$0.335 per gal	$ 20.10–22.11
12. Chlorate-Chloride	Sodium chlorate 3 lb/gal, calcium chloride 2½ lb/gal	50–60 gal conc	1:4	$0.48/gal	$ 24.00–28.00
13. Chlorax Granular 602	Sodium chlorate 60%, sodium metaborate 35%, 2,4-Dichlorophenoxyacetic acid 2%, inert ingredient 3%	800–1200 lb/a spot treatment fall or early spring—deep rooted perennials	Dry	Price not established	----------
14. Chlorax Liquid	Sodium chlorate 18.2%, sodium metaborate* 10%, inert ingredient 71.8%. *Equivalent to 1.67% boron as expressed as element boron.	80–100 gal	1:1 or 1:2 or 1:3	$0.385	$ 30.80–38.50

TABLE 10 (Continued)

Chemical	*Composition*	*Recommended Rate Per Acre*	*Dilution of Concentration Chemical:Water*	*Cost Per Lb or Gal*	*Cost Per Acre*
15. Chlorax "40" S.P.	Sodium chlorate 40%, sodium metaborate 57%	435–800 lb	Dry	$0.12	$ 52.20–96.00
16. Chlorea Granular No. 3	Sodium chlorate 40%, sodium metaborate 54%, (CMU)-3-(p-chlorophenyl)-1,1-dimethylurea 2.4% (Technical)	300–600 lb	Dry	$0.26 CL	$ 78.00–156.00
17. Chlorea Liquid 14	Sodium chlorate 18.2%, sodium metaborate 10% Telvar W 0.85%	50 gal	1:1 or 1:2 or 1:3	$0.63	$ 31.50
18. Chlorea Liquid 16	Sodium chlorate 18.2%, sodium metaborate 10%, Telvar W 1.3%	50 gal	1:1 or 1:2 or 1:3	$0.75	$ 37.50
19. Chlorea Liquid 18	Sodium chlorate 18.2%, sodium metaborate 10%, Telvar W 1.7%	50 gal	1:1 or 1:2 or 1:3	$0.87	$ 43.50
20. Concentrate Borascu	63% B_2O_3	2610–4356 lb	Dry	$0.0365	$ 95.26–158.99
21. Conoco Weed Spray Oil	Gravity, API 13; Flash, P.M. 220; Vis. at 100, SSU 42; Pour Point, °F. plus 15; Sulphur, % 1.1; Aromatics, %, D1019–51, 60; Color, Opaque, Distillation: I.B.P. 436; Recovered 10% 490°; 20% 512°; 50% 574°; 90% 670°, End Point 750°	75 gal	None	$0.0875/gal	$ 6.50
22. Diuron ("Karmex" Diuron Weed Killer*)	Diuron-3-(3,4-dichlorophenyl)-1,1-dimethylurea 80%	10–40 lb	Up to 0.5 lb per gal	$3.30	$ 33.00–132.00
23. 2,4-Dow Weed Killer Formula 40	Alkanolamine salts of 2,4-Dichlorophenoxyacetic acid 4 lb acid equiv./gal	1–2 gal	1:100	$2.50	$ 2.50– 5.00
24. Esteron Ten-Ten	Propylene glycol butyl ether ester of 2,4-Dichlorophenoxyacetic acid 4 lb acid equiv./gal	1–2 gal	1:100	$3.92	$ 3.92– 7.84
25. Garlon	Contains diethylene glycol bis 2,2 dichloropropionate and 2-(2,4,5-trichlorophenoxy) propionic acid Propylene glycol butyl ether esters	5–8 gal/acre in 150-300 gal water	----------	$5.75	$ 28.75–46.00
26. Granicide "A"	Sodium chlorate 14.50%, sodium perborate 3.00%, sodium sulfate 2.20%, 2,4-Dichlorophenoxyacetic acid 0.5%, active ingredient 20.20%, inert ingredient 79.80%	82.5 gal	1:3	$0.39	$ 32.18
27. Granicide 2X	Sodium chlorate 14.50%, sodium perborate 3.00%, sodium sulfate 2.20%, ammonium sulfamate 2.00%, active ingredient 21.70%, inert ingredient 78.30%	82.5 gal	1:3	$0.405	$ 33.41

TABLE 10 (Continued)

Chemical	*Composition*	*Recommended Rate Per Acre*	*Dilution of Concentration Chemical:Water*	*Cost Per Lb or Gal*	*Cost Per Acre*
28. HCA-Telvar	2% Hexachloroacetone, 4 lb Telvar 3-(chlorophenyl)-1,1-dimethylurea	100	98 gal	$0.50/gal	$ 50.00
29. HCA-2,4-D	2% Hexachloroacetone, 1% 2,4-D Amine	100	97 gal/oil	$0.48/gal mixture	$ 48.00
30. Herbicide (1¼ Caustic)	As_2O_3 4 lb per gal, NaOH 1¼ lb per gal	82.5 gal	1:3	$0.41	$ 33.83
31. Herbicide-NP	Sodium chlorate 3 lb per gal, calcium chloride 2.25 lb/gal	82.5 gal	1:3	$0.56	$ 46.20
32. Herbicidol Regular[1]	As_2O_3 13.00%, oil 51.80%, cresols 2.30%, xylenols 1.50%, phenols 0.60%, 2,4-Dichlorophenoxyacetic acid 0.50%, emulsifying, activating and penetrating agents 15.00%, active ingredient 84.70%, inert ingredient 15.30%	82.5 gal	1:3	$0.445	$ 36.71
33. Herbicidol-NP Regular[2]	Oil 21.40%, cresols 1.80%, xylenols 1.20%, phenols 0.50%, sodium trichloroacetate 7.00%, 2,4-Dichlorophenoxyacetic acid 1.10%, emulsifying, penetrating, binding and activating agents 12.00%, total active ingredient 45.00%, inert ingredient 55.00%	82.5 gal	1:3	$0.505	$ 41.66
34. Hykil-HCA Weed Killer	Aromatic oil+surfactants+2% hexachloroacetone by volume	75 100 gal	2 HCA:98 oil	$0.56	$ 52.00 56.00
35. Hykil-Monuron	Aromatic oil+surfactants with monuron	80 gal oil + 8 lb monuron	1:1 oil with water	$0.345	$ 27.60
36. Hykil Weed Killer No. 60	Aromatic oil and surfactants. Slightly varied specifications from various plants similar to previous	75-100 gal	None or 1:1 water with oil	$0.085-0.095	$ 6.37- 9.50
37. Methoxone-Chlorax Conc.	Sodium chlorate 16.3%, sodium metaborate 9.1%, 2-methyl-4-chlorophenoxyacetic acid .2%, inert ingredient +74.4%	80-100 gal	1:1	$0.393	$ 31.44 39.30
38. Methoxone-Chlorea No. 14	Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%, Telvar W 0.8%	50 gal	1:1 or 1:2 or 1:3	$0.639	$ 31.95
39. Methoxone-Chlorea No. 16	Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%, Telvar W 1.2%	50 gal	1:1 or 1:2 or 1:3	$0.759	$ 37.95
40. Methoxone-Chlorea No. 18	Sodium chlorate 16.3%, sodium metaborate 9.1%, MCP acid 0.4%, Telvar W 1.6%	50 gal	1:1 or 1:2 or 1:3	$0.879	$ 43.95

TABLE 10 (Continued)

Chemical	*Composition*	*Recommended Rate Per Acre*	*Dilution of Concentration Chemical:Water*	*Cost Per Lb or Gal*	*Cost Per Acre*
41. Monobor-Chlorate No. 2	Sodium borate 10%, sodium chlorate 7%, inert ingredients including wetting agent 83%	100–200 gal	----------	$0.155–0.17	$ 15.50–34.00
42. Monobor-Chlorate No. 6	Anhydrous sodium metaborate-$Na_2B_2O_4$—9.71%, Sodium chlorate—$NaClO_3$ 17.00%, 2,4-Dichlorophenoxyacetic acid 0.39%, inert ingredients including wetting agent 72.90%	75–112.5 gal	1:1 or 1:2	$0.34	$ 25.50–38.25
43. Monuron ("Telvar" monuron weed killer*)	Monuron-3-(p-chlorophenyl)-1,1-dimethylurea 80% active ingredient	10–40 lb	Up to 0.5 lb per gal	$2.60	$ 26.00–110.40
44. Nalco H-170	Aromatic petroleum oil 98%, pentachlorophenol 0.87%, 2,4-D iso-octyl ester 1.13%, (2,4-D acid equiv.—0.72%)	44 gal	None	$0.383/gal	$ 16.85
45. Nalco H-174	3-(p-chlorophenyl)-1,1-dimethylurea 8.0%, sodium tetraborate 83%, inert (surfactants) 9.0%	200–400 lb	Dry	$0.48 lb	$ 96.00–192.00
46. Nalco H-175D	2,4,5-Trichlorophenoxyacetic acid, propylene glycol butyl ether esters 30.0%, Aromatic petroleum oil including red dye 70.0%, 2,4,5-T acid equiv. 19.8%	2.5–4.0 gal	1:10 in diesel distillate fuel oil or kerosene	$5.60/gal	$ 14.00– 22.40
47. Nalco H-178D	Aromatic petroleum oil + surfactants 95.00%, pentachlorophenol 5.00%	20 gal	1:10	$0.52/gal	$ 10.40
48. No. 8764 Oil	Heavy aromatic oil	80–100 gal	None	$0.095/gal	$ 7.60– 9.50
49. Polybor Chlorate	Disodium octaborate 73%, sodium chlorate 25%, boron trioxide content 49%	800–1600 lb	Spray (2 lb/gal)	$0.09	$ 72.00–144.00
50. Radapon (Liquid)	2,2 dichloropropionic acid, 4 lb/gal 78% dalapon sodium salt	20–40 lb or 5–10 gal	1:32	$2.72–2.96	$ 13.60–29.60
51. Radapon-2,4-D	2,2 dichloropropionic acid, 2,4-Dichlorophenoxyacetic acid, amine salt	10 gal conc 2 gal conc	1:10 1:100	----------	$ 32.20
52. Radapon-Kuron	2,2 dichloropropionic acid, 2-(2,4,5-Trichlorophenoxy) propionic acid, propylene glycol butyl ether esters	10 gal conc 1–1½ gal conc	10:100 1–1½:100	----------	$ 35.71–39.97
53. Reade M/W-4 Dry Weed Killer	Sodium tetraborate decahydate ($Na_2B_4O_7 10H_2O$) 30.8%, sodium tetraborate pentahydrate ($Na_2B_4O_7 5H_2O$) 63.2%, 3-(p-chlorophenyl)-1,1-dimethylurea 4.0%, inert ingredient 2.0%	Annuals 218–435 lb Perennials 435–870 lb	Dry	$0.23–0.28	$ 50.14–243.00

TABLE 10 (Continued)

Chemical	*Composition*	*Recommended Rate Per Acre*	*Dilution of Concentration Chemical:Water*	*Cost Per Lb or Gal*	*Cost Per Acre*
54. Reade M/W-8 Dry Weed Killer	3-(p-chlorophenyl)-1,1-dimethylurea 8.0%, sodium tetraborate decahydrate ($Na_2B_4O_7 10H_2O$) 87.0%, inert ingredient 5.0%	Annuals 218–435 lb Perennials 435–870 lb	Dry	$0.42–0.47	$ 91.56–408.90
55. Reade 4X Weed Killer	Cresols 2.90%, xylenols 2.00%, phenols 0.80%, 2,4-Dichlorophenoxyacetic acid 2.30%, 3-(p-chlorophenyl)-1,1-dimethylurea 0.44%, sodium pentachlorophenate 0.27%, emulsifying, activating and penetrating agents 18.00%, active ingredient 26.71%, inert ingredient 73.2%	82.5 gal	1:3	$0.515	$ 42.49
56. RHB "Soil Sterilant"	3-(p-chlorophenyl)-1,1-dimethylurea 21.33%, inert ingredient 78.67%	112–150	Dry	$1.10	$123.00–165.00
57. RHB "Soil Sterilant"	3-(p-chlorophenyl)-1,1-dimethylurea 16%, inert ingredient 84%	112–150	Dry	$0.94	$105.00–141.00
58. Simazine 80W	2-chloro-4,6-bis-(ethylamino)-s-triazine 80%	25 lb		$3.25/lb	$ 40.63–81.25
59. Sodium Arsenite	Arsenic trioxide 4 lb/gal, sodium hydroxide 1 lb/gal	50–60 gal conc	1:4	$0.34	$ 17.00–21.00
60. Sodium Arsenite	4 lb active	20–80	1:3 oil	$0.45	$ 9.00–36.00 plus oil
61. Sodium TCA Solution	Sodium trichloroacetate 90% 6 lb per gal	7–15 gal	1:15 to 1:30	$1.69–1.93	$ 11.83–28.95
62. Standard 2,4-D Weed Killer No. 5	Butyl and isopropyl esters of 2,4-D 55.9%, equiv. to 45.0% by wt. 2,4-Dichlorophenoxyacetic acid, equal to 4 lb 2,4-D acid equiv/gal	2–4 pts	1:200–1:400	$3.75/gal	$ 0.94–1.88
63. TCA-Chlorate	Sodium trichloroacetate 90%, 1.25 lb per gal, sodium chlorate 99%, 2.5 lb/gal+additives and dye	32–40 gal	1:4	$0.85/gal	$ 27.20–34.00
64. TCA-Chlorate (Regular)	Sodium chlorate 2 lb/gal trichloroacetate 2/3 lb per gal	50–60 gal conc	1:4	$0.48	$ 24.00–28.50
65. TCA-Chlorate (Special A)	Sodium chlorate 2 lb/gal trichloroacetate 2/3 lb per gal, calcium chloride 1.2 lb per gal	50–60 gal conc	1:4	$0.52	$ 26.00–30.00
66. TCA-Chlorate (Special D)	Sodium chlorate 2½ lb/gal, trichloroacetate 1¼ lb/gal, calcium chloride 1½ lb/gal	45–50 gal conc	1:5	$0.76	$ 35.00–38.00
67. TCA-Chlorax	Sodium chlorate 14.2%, sodium metaborate 7.93%, sodium trichloroacetate 2.61%	80–100 gal		$0.40	$ 32.00–40.00

TABLE 10 (Continued)

Chemical	Composition	Recommended Rate Per Acre	Dilution of Concentration Chemical:Water	Cost Per Lb or Gal	Cost Per Acre
68. Trysben 200 Weed Killer†[3]	Dimethylamine salt of trichlorobenzoic acid 24.8%, dimethylamine salt of other polychlorobenzoic acid 1.3%. Total active ingredients 26.1%	5–10 gal	1 gal/10–20 gal	$10.00/gal	$ 50.00–100.00
69. Urab Granular	22% 3-phenyl-1,1-dimethylurea trichloroacetate	80–200	None	$1.05 C/L 50 lb drums	$ 84.00–210.00
70. Urab Liquid	3 lb active ingredient	5–9 gal	100 gal water or oil	$13.00 55 gal drums	$ 65.00–117.00
71. Ureabor	Disodium tetraborate pentahydrate 63.2%, disodium tetraborate decahydrate 30.8%, 3-(p-chlorophenyl)-1,1-dimethylurea 4%	400–800 lb	Dry	$0.24	$ 96.00–192.00
72. Urox 11	3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate 11%	250–400 lb	None	$0.50/lb	$125.00–200.00
73. Urox 22	3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate 22%	125–200 lb	None	$0.841 lb	$105.00–163.00
74. Urox Liquid	3 lb/gal, 22% 3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate	4 gal	100 gal oil or water	$12.00/gal	$ 48.00+oil
	BRUSH				
1. "Ammate" X Weed and Brush Killer	Ammonium Sulfamate 95%	179–269	60 lb/100 gal water+4 oz Spreader-sticker	$0.272 in 300 to 2,000 lb quantities	$ 48.68–73.17
2. Ammate Weed and Brush Killer Solution†	Contains 5.6 lb "Ammate" X per gal	32–48 gal	10.7 gal/100 gal	$0.86/gal	$ 27.52–41.28
3. Brush Killer 22	Iso-octyl ester of the 2,4-Dichlorophenoxyacetic acid 33.7%, Iso-octyl ester of the 2,4,5-Trichlorophenoxyacetic acid 32.1%, inert ingredient 34.2%, total ingredient 100%	1.65–2 gal	1:113–1:150		$ 14.00–20.00
4. Esteron 245 O.S.	Propylene glycol butyl ether ester 2,4,5-Trichlorophenoxyacetic acid 4 lb acid equiv/gal	2–3 gal conc	1:100–1:125	$7.95	$ 15.90–23.85
5. Esteron Brush Killer O.S.	Propylene glycol butyl ether ester-2,4-Dichlorophenoxyacetic acid 2 lb acid equiv/gal and propylene glycol butyl ether ester-2,4,5-Trichlorophenoxyacetic acid 2 lb acid equiv/gal	2–3 gal conc	1:100–1:125	$5.82–6.30	$ 11.64–18.90

TABLE 10 (Continued)

Chemical	*Composition*	*Recommended Rate Per Acre*	*Dilution of Concentration Chemical:Water*	*Cost Per Lb or Gal*	*Cost Per Acre*
6. Fenuron ("Dybar" Fenuron Weed and Brush Killer Pellets*)[4]	Fenuron (3-phenyl-1,1-dimethylurea) 25% active ingredient	50 75 lb	applied as fomulated	$1.05 lb	$ 52.50 78.75
7. Kuron	Low volatile propylene glycol butyl ether ester, 2-(2,4,5-Trichlorophenoxy) propionic acid 4 lb acid equiv. gal	1 1½ gal conc	1 to 1½:100	$8.51	$ 8.51 12.77
8. Line Rider LV-6T-O.S.[5]	(Low volatile) 2-ethyl hexyl esters of 2,4,5-Trichlorophenoxyacetic acid 6 lb acid equiv per gal	up to 2 gal conc (maximum conc broadcast)	1:100 diesel oil or No. 2 fuel oil	$10.71 55 gal drums	$ 21.42 + oil
9. Low Volatile Brush Killer	Acid equivalent 4 lb. gal	*Foliage Spray* 1 gal to 100 to 150 gal water. Add 0.1% by wt. wetting agent *Basal Dormant or Stump* 1 gal in 24 gal diesel oil wet foliage	*Foliage Spray* 1:100 1:150 *Basal Dormant or Stump* 1:24 oil	$6.63 LCL	$ 13.26 19.89
10. Low Volatile Ester 2,4,5-T	Acid equiv 4 lb./gal	Wet foliage 2 3 gal conc	1:100	$8.60 LCL	$ 17.20 25.80
11. Standard Brush Killer	Iso-octyl esters of 2,4-D and 2,4,5-T 66.6%, equal to 2 lb./gal of 2,4-Dichlorophenoxyacetic acid and 2 lb./gal 2,4,5-Trichlorophenoxyacetic acid	2 3 gal	1:100 1:125	$7.02/gal	$ 14.04 21.06
12. Trysben 200 Weed Killer[3]†	Dimethylamine salt of Trichlorobenzoic acid 24.8%. Dimethylamine salt of other Polychlorobenzoic acid 1.3%. Total active ingredients 26.1%	2 6 gal	2 gal/100	$10.00/gal	$ 20.00 60.00
13. Veon Brush Killer	Amine formulation 2,4-Dichlorophenoxyacetic acid 2 lb acid equiv/gal conc, 2,4,5-Trichlorophenoxyacetic acid 2 lb acid equiv/gal	2 3 gal conc	1:100 1:125	$5.82 6.30 Note: Price not developed but is in this range	$ 11.64 18.90
14. Veon 245	Amine salt formulation 2,4,5-Trichlorophenoxyacetic acid 4 lb acid equiv/gal	2 3 gal conc	1:100 1:125	$7.95 8.113	$ 15.90 24.34

TABLE 10 (Continued)

Chemical	*Composition*	*Recommended Rate Per Acre*	*Dilution of Concentration Chemical:Water*	*Cost Per Lb or Gal*	*Cost Per Acre*
	SURFACTANTS—WETTING AGENTS				
		Amt/100 Gal			
1. Triton X-100	Alkyl Aryl Polyether alcohol	4–8 oz	----------	$0.27 lb	----------
2. Triton X-114	Alkyl Aryl Polyether alcohol	4–8 oz	----------	$0.27 lb	----------
3. Triton B-1956	Modified phthalic glyceral alkyd resin	4–8 oz	----------	$4.80 gal	----------
4. Du Pont Spreader-Sticker	Sodium sulfates of mixed long chain alcohol fatty acid esters. Diethylene glycol abietate	2–8 oz	----------	$6.50 gal	----------

[1]Herbicidol Regular also supplied with additives.
[2]Herbicidol-NP Regular also supplied with additives.
[3]Recommended only for controlling conifers, sumac, and hackberry at the present.
[4]Registered for use in all areas east of the Rocky Mountains.
[5]Line Rider LV-6T-OS—Volume required for cane broadcast depends on density of vegetation. Recommended rate based on 200 gal (Maximum volume) solution per acre using off-track equipment.
*Truckload or carload quantities.
†F.O.B. nearest stockpoint.

Report of Committee 4—Rail

L. S. Crane, *Chairman,*
W. J. Cruse,
Vice Chaiman,
A. P. Talbot, *Secretary,*
W. D. Almy
John Ayer, Jr.
S. H. Barlow
G. V. Begany, Jr.
H. B. Berkshire
F. W. Biltz
Flair Blowers
B. Bristow
C. B. Bronson (E)
R. M. Brown
J. A. Bunjer
T. F. Burris
R. E. Catlett, Jr.
E. E. Chapman (E)*
C. J. Code
C. A. Colpitts
C. O. Conatser
G. H. Echols
D. T. Faries
O. E. Fort
J. K. Gloster
C. E. R. Haight
V. E. Hall
C. J. Henry
C. C. Herrick
W. H. Hobbs
S. R. Hursh
T. B. Hutcheson
J. C. Jacobs
W. M. Jaekle
K. K. Kessler
R. F. Lawson
H. S. Loeffler
Lee Mayfield
Ray McBrian
B. R. Meyers
C. E. Morgan
Embert Osland
W. H. Penfield (E)**
G. L. P. Plow
R. B. Rhode
C. R. Riley
J. G. Roney
E. F. Salisbury
J. K. Shaffer
S. H. Shepley
W. D. Simpson
H. F. Smith
J. S. Wearn
H. F. Whitmore
R. P. Winton
Edward Wise, Jr.***
W. L. Young
Committee

(E) Member Emeritus.
* Died August 19, 1959.
** Died June 1, 1959.
*** Died August 30, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, including recommended revisions ..... page 832

2. Collaborate with AISI Technical Committee on Rail and Joint Bars in research and other matters of mutual interest.
   Progress report, including as Appendix 2–a, Report on Investigation of Failures in Control-Cooled Railroad Rails ..... page 835

3. Rail failure statistics, covering (a) all failures; (b) transverse fissures; (c) performance of control-cooled rail.
   Progress report, including statistics on rail failures reported up to December 31, 1958 (on net ton basis) ..... page 845

4. Rail end batter; causes and remedies.
   In the program being carried out to evaluate various welding methods and rods for the repair of battered rail ends, the rolling-load tests have been completed and the metallurgical investigation is in progress.

5. Economic value of various sizes of rail.
   Progress report, presented as information ..... page 867

6. Service tests of various types of joint bars.

   Since little change has developed in the service tests being conducted on the Santa Fe and C&NW, under this assignment, no formal report is presented It is planned to make another series of observations and measurements in 1960, looking to presenting a final report.

7. Joint bar wear and failures; revision of design and specification for new bars, including insulated joints, and bars for maintenance repairs.

   At the request of the Signal Section, AAR, the committee has begun an investigation to develop means or methods for deriving greater life from, and reliability in, insulated rail joints of the six-hole design for rail sections of 115-lb and heavier. It is hoped that a progress report on this investigation can be presented next year.

8. Causes of shelly spots and head checks in rail; Methods for their prevention.

   Progress report, presented as information ..... page 869
   Appendix 8–a—Report on service tests of heat-treated and alloy-steel rails . page 870
   Appendix 8–b—Report on shelly rail studies at University of Illinois ..... page 874

9. Standardization of rail sections.

   Progress report, presented as information ..... page 881

10. Service performance and economics of 78-ft rail, collaborating with Committee 5; specifications for 78-ft rail.

    Progress report, presented as information ..... page 883

11. Rail damage resulting from engine burns; prevalence; means of prevention; repair by welding.

    Progress report, presented as information ..... page 888

THE COMMITTEE ON RAIL,
L. S. CRANE, *Chairman.*

AREA Bulletin 556, February 1960.

MEMOIR

Edmund Earl Chapman

Edmund Earl Chapman, retired mechanical assistant (research and engineering) of the Santa Fe Railway System at Chicago, passed away suddenly on August 19, 1959, in his 76th year. He is survived by his widow, two daughters, and two sons.

Mr. Chapman was born in Mankato, Kans., on January 3, 1884. After his graduation from Purdue University with a B.S. Degree in Mechanical Engineering, he began his railroad career in the Test Department of the Santa Fe at Topeka, Kans., on December 11, 1909. During the first World War he was on special assignment in the U. S. Army Ordnance Department, returning to the Santa Fe in June 1919 as assistant engineer of tests. He was appointed engineer of tests in March 1921, and was promoted to mechanical assistant at Chicago on April 1, 1938, continuing in that capacity until his retirement on January 31, 1954.

Mr. Chapman joined the American Railway Engineering Association in 1923 and became a Life Member in 1954. He was active in committee work, giving generously of his time to the Tie committee, 1929–1937, and the Rail Committee from 1928 until

his retirement, being elected a Member Emeritus of this committee on August 4, 1954.

During his service in the Santa Fe's Test Department he became particularly interested in rail and track fastenings and was very helpful to the Rail committee in any problems that had to do with joint bar and rail failures, and metallurgy in general. He was chairman of the subcommittee on "Joint Bar Wear and Failures" from 1949 to 1954 and was responsible for important changes in specifications brought about by this subcommittee.

While working with Dr. Sperry in designing a gyro-equipped car for evaluating track surface conditions, Mr. Chapman interested Dr. Sperry in laboratory testing equipment, the basic principle of which was used in the original Sperry rail detector car.

It is with profound regret that the Association expresses its sorrow for the loss of a capable and devoted member.

B. R. Meyers,
C. J. Code,
Ray McBrian,
Committee on Memoir.

MEMOIR

Edward Wise, Jr.

Edward Wise, Jr., 66, engineer maintenance of way on the Louisville & Nashville Railroad, passed away on August 30, 1959, as the result of a heart attack. He is survived by his widow, a daughter, two grandchildren, a brother and a sister.

Mr. Wise was born at Henderson, Ky., on January 15, 1894, and after graduating from the University of Kentucky and doing some construction work, he started his railroad career on the L. & N. as a rodman on June 9, 1913. Thereafter, he worked in various capacities in the Engineering Department, including resident and division engineer, until his advancement to engineer maintenance of way on October 1, 1943.

He joined the American Railway Engineering Association in 1940, becoming a member of several committees; Roadway and Ballast, 1945–49; Rail, 1952 until the time of his death; Economics of Railway Labor, 1940–1952; and the Special Committee on Continuous Welded Rail, 1952 until his death.

Mr. Wise was a diligent worker on these committees, giving generously of his time and ability to further their accomplishments. His friendly manner, which they were privileged to share for so many years, will be greatly missed by his fellow committee members, and it is with deep regret that the Association expresses its sorrow in his passing.

B. R. Meyers,
C. J. Code,
Ray McBrian,
Committee on Memoir.

MEMOIR

William Henry Penfield

William Henry Penfield, 84, retired chief engineer of the Chicago, Milwaukee, St. Paul & Pacific Railroad, a director of the AREA from 1942 to 1946, its treasurer from 1937 to 1943, and Member Emeritus of Committee 4—Rail, died on June 1, 1959. A complete memoir on Mr. Penfield was published in Bulletin 552, September–October 1959, and will appear in the 1960 Proceedings.

Report on Assignment 1

Revision of Manual

W. J. Cruse (chairman, subcommittee), H. B. Berkshire, F. W. Biltz, L. S. Crane, V. E. Hall, C. C. Herrick, W. H. Hobbs, H. S. Loeffler, Ray McBrian, G. L. P. Plow, R. B. Rhode, S. H. Shepley, J. S. Wearn. H. F. Whitmore, Edward Wise, Jr.

Your committee submits the following recommendations with respect to Chapter 4 of the Manual:

Pages 4–1–16 to 4–1–19, incl.

DESIGN FOR TRACK BOLTS AND NUTS

Reapprove with the following revisions:

Eliminate provision for 1¼-in-diameter track bolts and nuts from Table 1, page 4–1–17; Table 2, page 4–1–18; and Table 3, page 4–1–19.

Pages 4–2–15 to 4–2–18, incl.

SPECIFICATIONS FOR HEAT-TREATED CARBON-STEEL AND ALLOY-STEEL TRACK BOLTS, AND CARBON-STEEL NUTS

Reapprove with the following revisions:

Withdraw all data pertaining to alloy steel for track bolts, as follows:

On page 4–2–15 eliminate in the title the words: "AND ALLOY-STEEL".

Eliminate in Art. 1. Scope, the words: "and alloy-steel".

Eliminate in Art. 3. Chemical Composition, the column headed "Alloy-Steel", and the note reading as follows: "The type of alloy to be used shall be agreed upon between the manufacturer and the purchaser."

Eliminate in Art. 4. Ladle Analysis, Par. (b), the following: "also any alloy element used."

On page 4–2–16 eliminate in Art. 6. Tension Tests, the column headed "Alloy-Steel."

Eliminate in Art. 8. Bend Tests, all of Par. (b).

On page 4–2–17 eliminate in Art. 9. Strip Test, the column headed "Alloy-Steel 115,000 Psi."

On page 4–2–17, Art. 9. Strip Test, eliminate reference to 1¼-in bolt.

On page 4–2–18, change Art. 13, Par. (b), to read as follows:

"*(b) Wrench turn fit.*—The nut shall have a free fit for at least two threads in starting on the bolt. When engaged for the thickness of the nut plus two threads, the nut shall show the following minimum and maximum resistance, and for the remainder of the screw length shall not exceed the maximum resistance to turning as expressed in pounds pull applied to the end of a 24-in wrench."

Your committee also recommends for adoption the following data on shells and related gage corner developments, to be added to Chapter 4 of the Manual, Miscellaneous Part, as pages 4–M–11 and 4–M–12.

ILLUSTRATIONS OF SHELLS AND RELATED GAGE CORNER DEVELOPMENTS

Head Check.—Hair line cracks which appear in the gage corner of the rail head, at any angle with the length of the rail. When not readily visible the presence of the checks may often be detected by the raspy feeling of their sharp edges (Fig. 1).

Flaking.—Where small shallow flakes of surface metal generally not more than ¼ in. in length or width break out of the gage corner of the rail head (Fig. 2).

Shelly Spots.—Where a thin (usually ⅜ in. in depth or less) shell-like piece of surface metal becomes separated from the parent metal in the rail head, generally at the gage corner. It may be evidenced by: (a) a black spot appearing on the rail head over the zone of separation (Fig. 3a); (b) a piece of metal breaking out completely, leaving a shallow cavity in the rail head (Figs. 3b and 3c). In the case of a small shell there may be no surface evidence, the existence of the shell being apparent only after the rail is broken or sectioned.

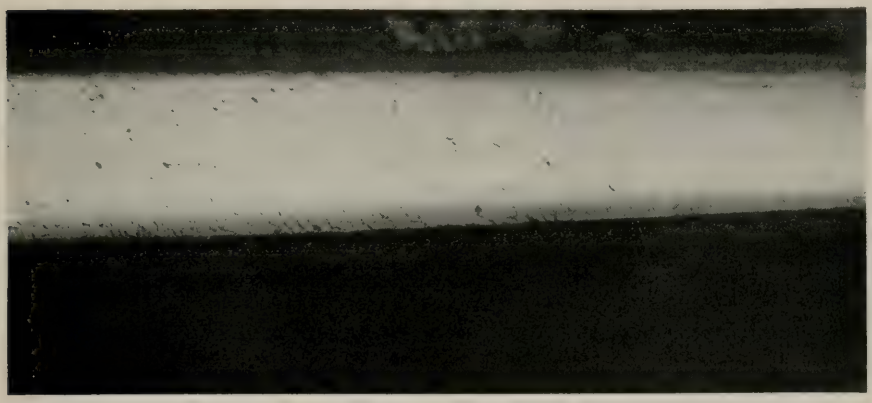

Fig. 1.

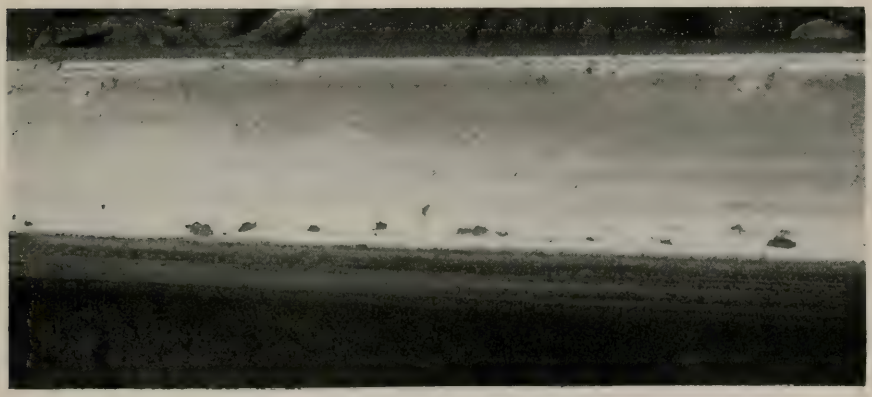

Fig. 2.

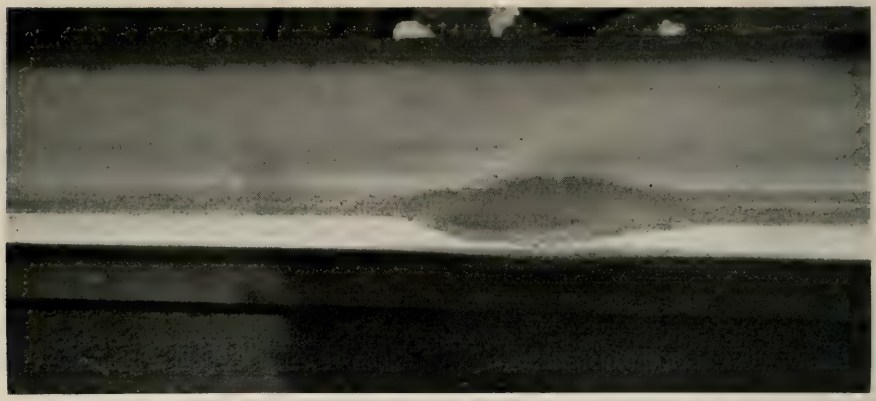

Fig. 3a.

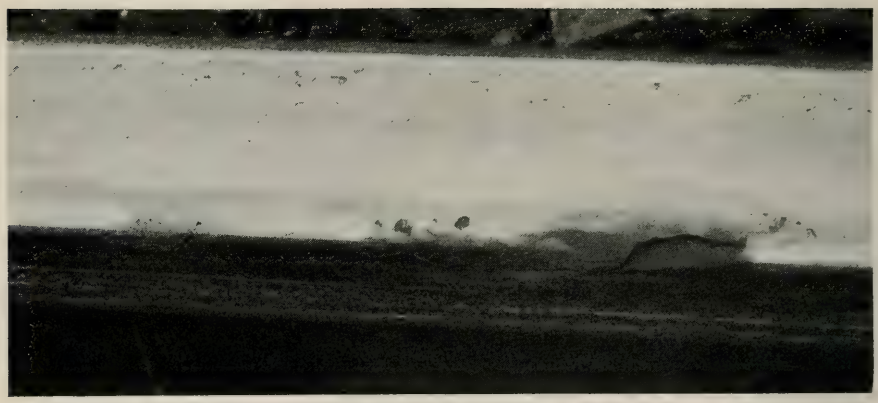

Fig. 3b—Light shell.

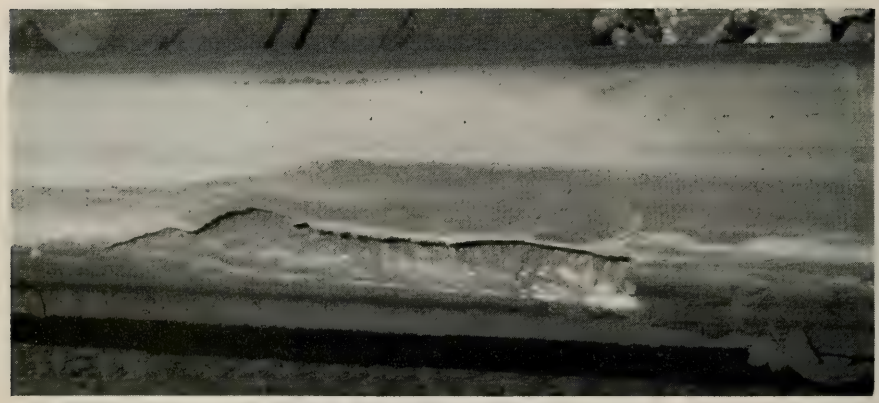

Fig. 3c—Heavy shell.

Report on Assignment 2

Collaborate with AISI Technical Committee on Rail and Joint Bars in Research and Other Matters of Mutual Interest

L. S. Crane (chairman, subcommittee), G. V. Begany, Jr., J. A. Bunjer, C. J. Code, C. A. Colpitts, W. J. Cruse, D. T. Faries, W. H. Hobbs, T. B. Hutcheson, J. C. Jacobs, W. M. Jaekle, K. K. Kessler, Ray McBrian, B. R. Meyers, Embert Osland, R. P. Winton.

This committee sponsors two studies which are being conducted at the University of Illinois under the direction of Professor R. E. Cramer. The report on the first of these studies is presented below as Appendix 2–a, entitled "Investigation of Failures in Control-Cooled Rails." The second is reported as Appendix 8–b of Assignment 8, entitled "Shelly Rail Studies at the University of Illinois."

The committee and the AISI are jointly reviewing specifications, and certain suggested revisions are presented in the report on Assignment 1.

Appendix 2–a

Investigation of Failures in Control-Cooled Rails

By R. E. Cramer

Research Associate Professor of Engineering Materials, University of Illinois

Organization and Acknowledgment

This investigation is financed equally by the Association of American Railroads and the American Iron and Steel Institute. Student Assistant Ray A. Dahman worked on this investigation on a part-time basis.

Control-Cooled Rails Which Failed in Service

Since the last report on October 1, 1958, reports have been prepared on 25 control-cooled rails sent to this laboratory as failed rails. These reports are sent to the railroad engineers supplying the failed rails, and copies go to the rail manufacturer and the director of engineering research, AAR, for the Association's rail-failure statistics.

Table 1 gives a summary of the 25 failures and Table 2 lists each rail separately.

Table 1—Summary of Failed Control-Cooled Rails

Transverse fissures from shatter cracks	1
Transverse fissures from hot-torn steel	3
Transverse fissures from slag inclusion	1
Shelling only	1
Vertical split head from fishtail	1
Fracture at electric weld on tread	2
Detail fracture from shelling	1
Vertical split web from fishtail	4
Horizontal split head from segregation	1
Shelled chrome-vanadium rail	1
Vertical split head from segregation	1
Fractured in derailment	1
Fracture at welded engine burn	1
Horizontal split head and vertical split head from fishtail	1
Vertical split head from porosity in hand weld	2
No failure found	2
Shallow surface crack on tread	1
Total	25

TABLE. 2—FAILED CONTROL-COOLED RAILS EXAMINED BETWEEN OCTOBER 1, 1958, AND OCTOBER 1, 1959

T.F. = Transverse Fissure; D.F. = Detailed Fracture; V.S.H. = Vertical Split Head; H.S.H. = Horizontal Split Head

Source of Failed Rail	*Lab. Failed Rail Number*	*Size of Rail*	*Mill*	*Heat Number Rail Letter Ingot Number*	*Date Rolled*	*Classification of Failure*
CP	996	130	Algoma	22709–D–18	12–1941	No failure found
IC	997	90	Gary	811431–I–21	7–1946	Shelling only
GN	998	132	Gary	595431–E–28	4–1953	V.S.H. from fishtail
CP	999	100	Algoma	22254–E–22	3–1941	Fracture at electric weld on tread
CP	1000	100	Algoma	3837–C–2	3–1941	Fracture at electric weld on tread
CP	1001	100	Dominion	3582–A–13	7–1931	D.F. from shelling
GN	1002	115	Inland	3567–H–10	1956	Vertical split web from fishtail
NYC&StL	1003	115	Inland	27522–G–10	2–1952	T.F. from hot-torn steel
CP	1004	100	Algoma	5091–B–13	1–1950	T.F. from shatter crack
GN	1005	115	Lackawanna	10311–A–23	5–1953	H.S.H. from segregation
SP	1006	136	Colorado C. V.	5263–D–9	4–1956	Shelled chrome-vanadium rail
GN	1007	112	Colorado	3499–A–13	8–1955	V.S.H. from segregation
CNJ	1008	131	Bethlehem	89230–A–13	1952	Fractured in derailment
NYC	1009	127	Gary	57099–B–23	2–1940	Fracture at welded engine burn
IC	1010	115	Inland	25748–H–11	4–1953	H.S.H. and V.S.H. from fishtail
C&O	1011	132	Inland	15712–D–15	9–1955	T.F. from hot-torn steel
IC	1012	115	Tennessee	888134–C–6	3–1953	V.S.H. from porosity in hand weld
IC	1013	115	Tennessee	888134–D–17	3–1953	V.S.H. from same porosity as 1012
N&W	1014	132	E Thomson	16E033–E–24	1–1952	T.F. from large inclusion
CP	1015	100	Algoma	21924–J–5	1954	Vertical split web from fishtail
CP	1016	100	Algoma	25394–I–20	1954	Vertical split web from fishtail
CP	1017	100	Algoma	26255–J–8	1954	Vertical split web from fishtail
C&O	1018	132	Inland	29054–G–12	1954	T.F. from hot-torn steel
CP	1019	100	Algoma	23051–E–2	3–1938	No defect found
CP	1020	100	Algoma	23478–F–9	7–1941	Surface crack on tread

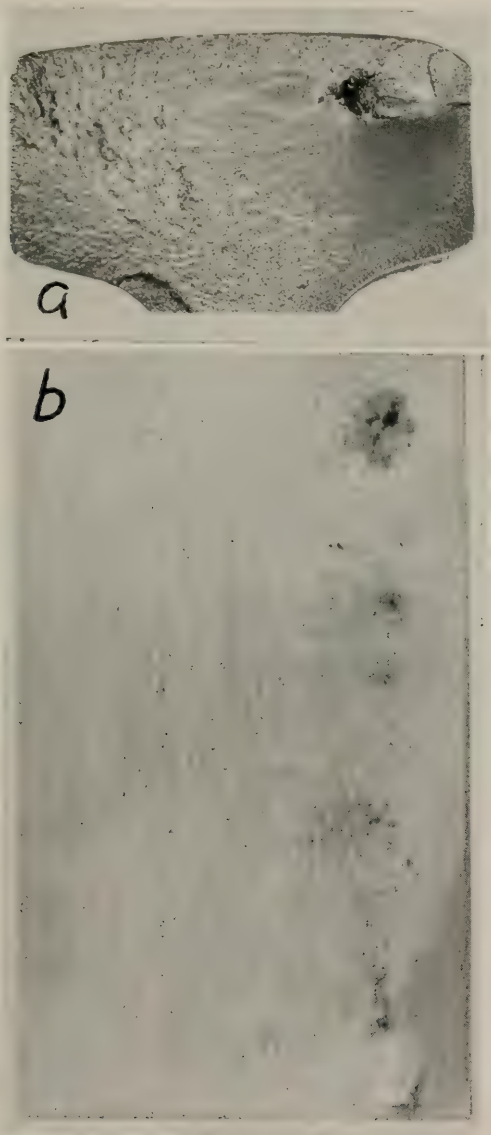

Fig. 1—Rail No. 1003—Transverse fissure from hot-torn steel.

a. Fracture showing porous nucleus of fissure.

b. Etched section from rail head showing additional hot-torn spots in steel.

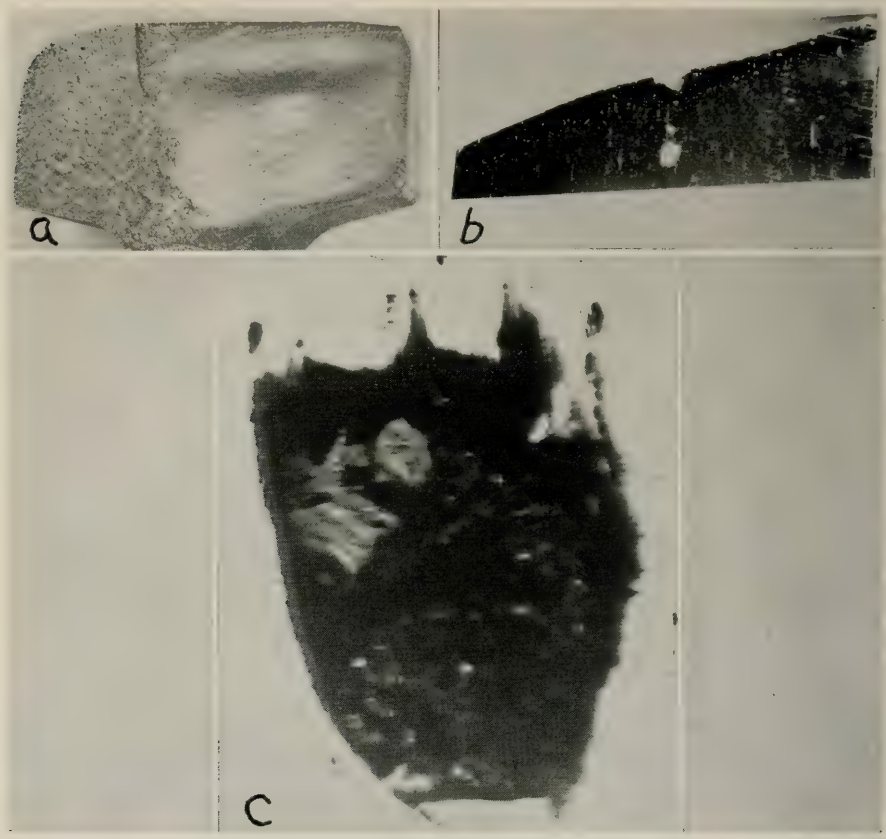

Fig. 2—Rail No. 1014—Transverse fissure from large inclusion.

a. Transverse fissure with small nucleus.

b. Polished specimen through nucleus. Magnification about 3×. Nucleus along fracture is in line with large inclusion in steel.

c. Large inclusion at about 60× magnification, showing complex structure.

Transverse Fissure from Shatter Crack

Only one transverse fissure from a shatter crack was found. It was in rail rolled at the Algoma Mill before its containers were supplied with tight-fitting lids late in 1950.

Transverse Fissure From Hot-Torn Steel

There were three transverse fissures from hot-torn steel, all in rails from the Inland Mill rolled in 1952, 1954, and 1955. The number of failures from this cause has decreased considerably in the last few years. Fig. 1 shows the fracture and an etched slice from the head of rail No. 1003.

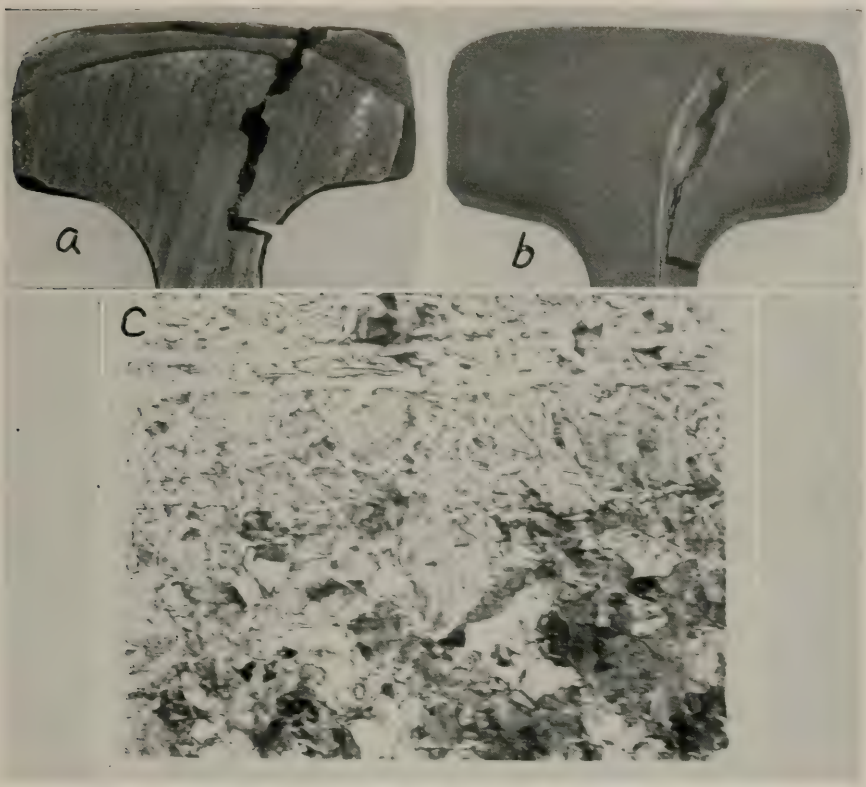

Fig. 3—Rail No. 998—Vertical split head from fishtail structure.

a. End of rail showing vertical split head.
b. Etched cross section showing white metal in fishtail structure.
c. Photomicrograph at about 70× magnification showing white ferrite in decarburized rail steel.

Transverse Fissure From Slag Inclusion

This defect was in rail No. 1014 and is shown in Fig. 2. Part a of Fig. 2 shows a 60-percent transverse fissure with a very small nucleus. Etch tests showed the rail to be free of porosity, so it was necessary to polish a specimen for metallographic examination to find the large inclusion shown in Parts b and c of Fig. 2. It is assumed that there had been another inclusion at the nucleus of the fissure which had dropped out.

Vertical Split Head From Fishtail

A picture of the end of rail No. 998 is shown in Fig. 3a. It had developed a vertical split head. Fig. 3b is an etched slice close to the rail end, whch explains why the vertical split head developed. This shows a rolling defect known as "fishtail" which occurs toward the end of the bottom rail in the ingot. The white metal shown in Part b is shown at about 70X magnification in Part c, where it will be recognized as ferrite or iron.

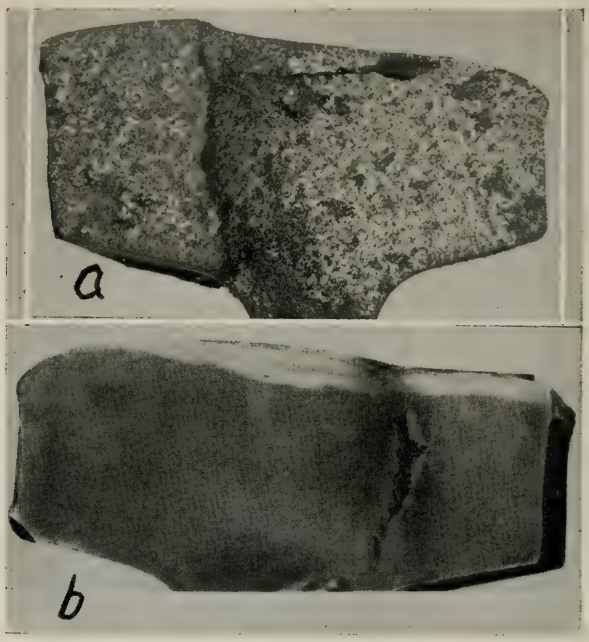

Fig. 4—Rail No. 1009—Fracture from welded engine burn.

a. Fracture showing horizontal and small vertical crack.
b. Opposite half of fracture ground smooth, except dark area on the right side. Etched in ammonium persulfate to show weld-deposited metal on rail tread.

Fracture From Welded Engine Burn

Only one failure was a fracture from welded engine burn. It is shown in Fig. 4, in which Part a shows the fracture. At the top of the right side there are a horizontal crack and a small vertical crack. Part b shows the opposite face of the fracture ground smooth except on the right side there is a rough, dark part of the fracture remaining. This ground specimen was etched with ammonium persulfate which shows the weld-deposited metal along the tread of the rail as white compared to the rail steel.

Vertical and Horizontal Split Head from Fishtail Structure

Fig. 5a shows the end of a rail which had developed both a horizontal split head and a vertical split head, a large area of the rail head had broken off. Fig. 5b is an etched cross section and shows that this rail contained a fishtail rolling defect which caused the failure.

Vertical Split Head from Porosity in Hand-Made Butt Weld

Two rails that were hand butt welded and used in a road crossing with joint bars attached developed long split heads; in the joint bar area the crack was not visible on the rail tread. A vertical cut was made near the weld line, as shown in Part a of Fig. 6.

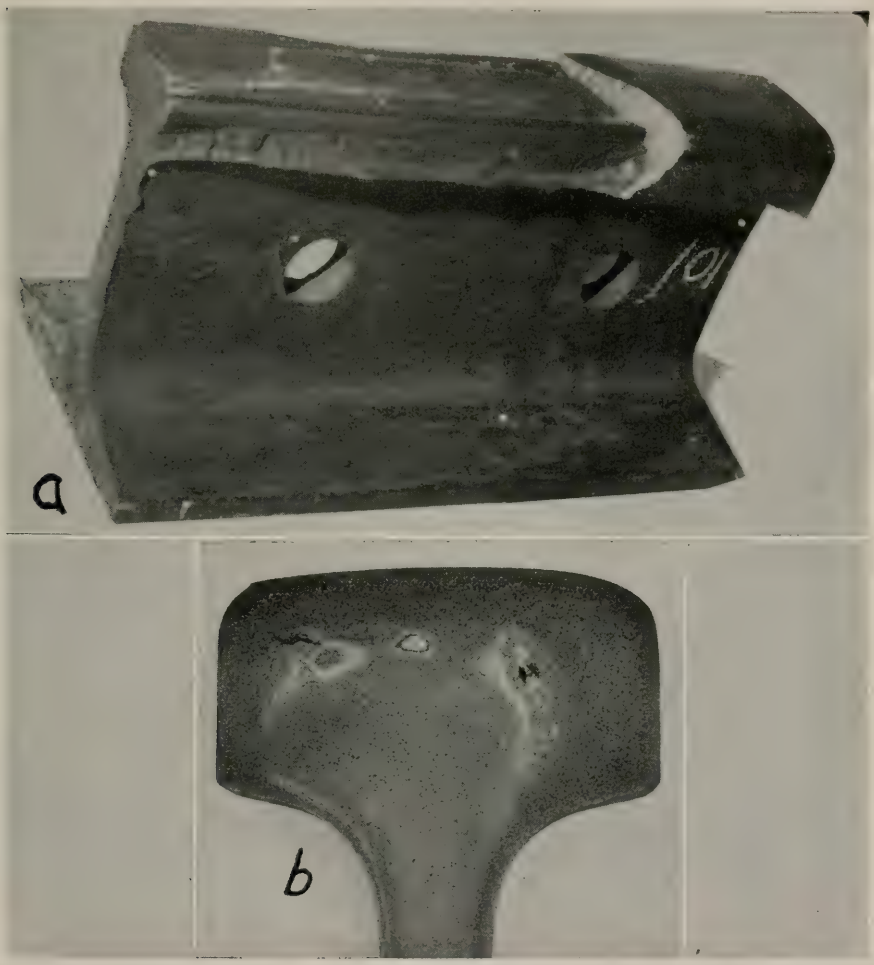

Fig. 5—Rail No. 1010—Vertical and horizontal split head from fishtail structure.

a. Rail showing both vertical split head and horizontal split head failure.
b. Etched cross section showing rolling defect known as fishtail structure.

This picture was taken after the crack had been extended to the tread. Two porous spots are visible in the weld-deposited metal. Fig. 6b shows the vertical face of the fracture and the dark porous spot from which the vertical split head developed.

Bend Tests of Corroded Rail

The Erie Railroad furnished two 112-lb corroded rails, one of which is shown in Fig. 7. It will be seen that there is rather deep corrosion at the junction of the web and base. Two new 112-lb rails were also furnished, and bend tests were made on all four

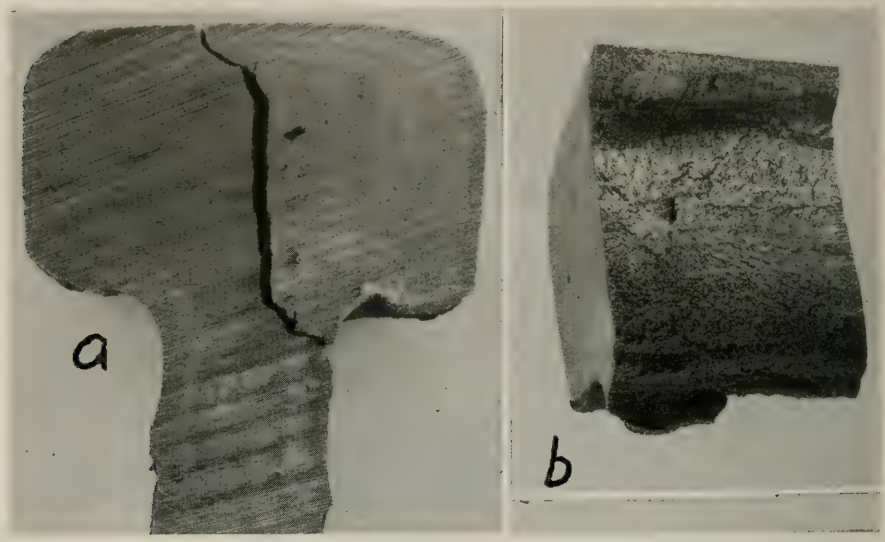

Fig. 6—Rail No. 1013—Vertical split head from porosity in hand-made butt weld.

a. Cross section near weld showing vertical split head and gas pockets in deposited weld metal.
b. Longitudinal fracture of vertical split head showing the gas pocket from which the failure developed.

specimens. The results of the bend tests are shown in Table 3. The tests were made on a 600,000-lb testing machine using supports 48 in apart and loaded at 2 points 1 ft apart. All tests were made with the base in tension.

TABLE 3—BEND TESTS RESULTS ON 112-LB RAILS

Specimen	*Maximum Load Lb*	*Energy for 4-in Bend, Ft-Lb*	*Deflection, Inches, at Maximum Load*
Corroded specimen No. 1	319,600	87,000	3
Corroded specimen No. 2	340,000	93,300	3.2
New rail No. 1	402,000	105,000	4
New rail No. 2	402,000	108,000	4

The used rails were head worn as well as corroded, so they bent easier than the new rails. The results of these bend tests did not indicate that the rails were unsafe to remain in track, but it is obvious that such rails should be inspected often for fatigue cracks in the rail webs. It would be better to make rolling-load tests rather than bend tests to determine the effect of the corrosion on these corroded rails. Rolling machines suitable for these tests are no longer located at the University laboratory.

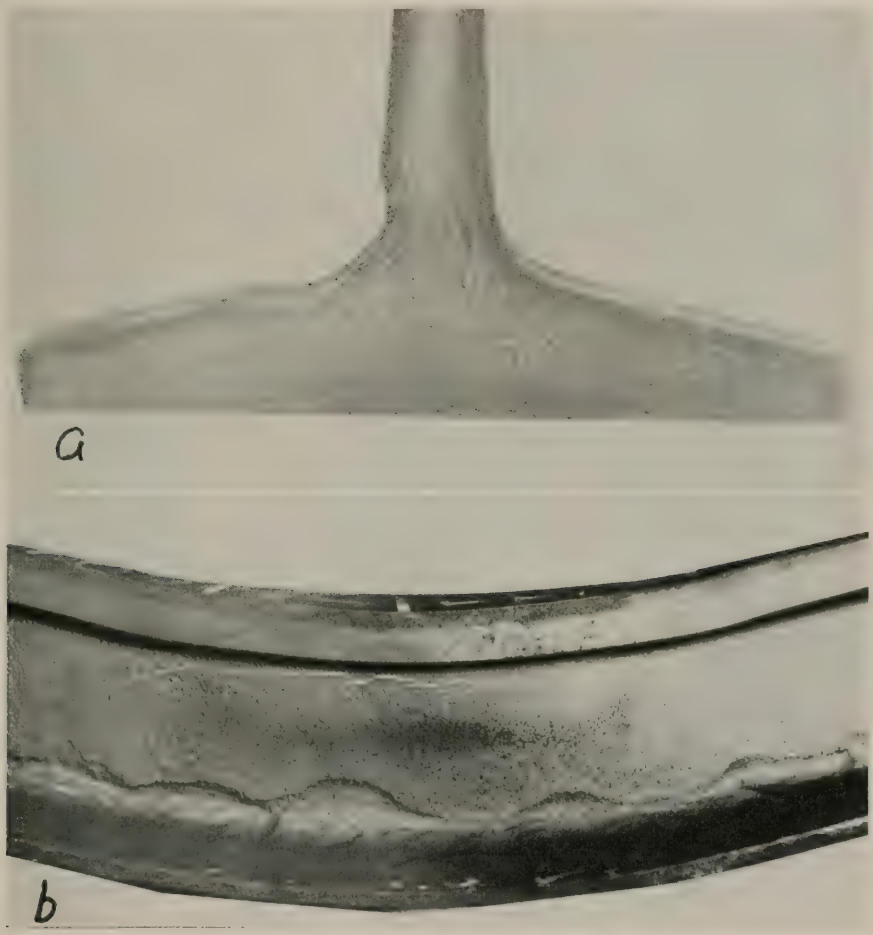

Fig. 7—Erie corroded rail No. 2.

a. Cross section showing depth of corrosion.
b. Bend test specimen after crack developed in rail web.

Three Rails with Vertical Split Webs from Fishtails

Rails Nos. 1015, 1016, and 1017 are shown in Fig. 8. Each rail has a large crack or separation of the steel in the rail web which extends up into the rail heads. These rails had all been in service approximately 4 years when the defects were located by a portable ultrasonic flaw detector while testing rail joints. Each of the rails was the bottom rail of the ingot, and these defects were all on the rail end nearest the bottom of the ingot, so they are presumed to be from fishtails. It is interesting to know that such defects can be located with ultrasonic flaw detectors. It would also be interesting to know if web cracks could be detected in the mill inspection of new rails by ultrasonic flaw detectors.

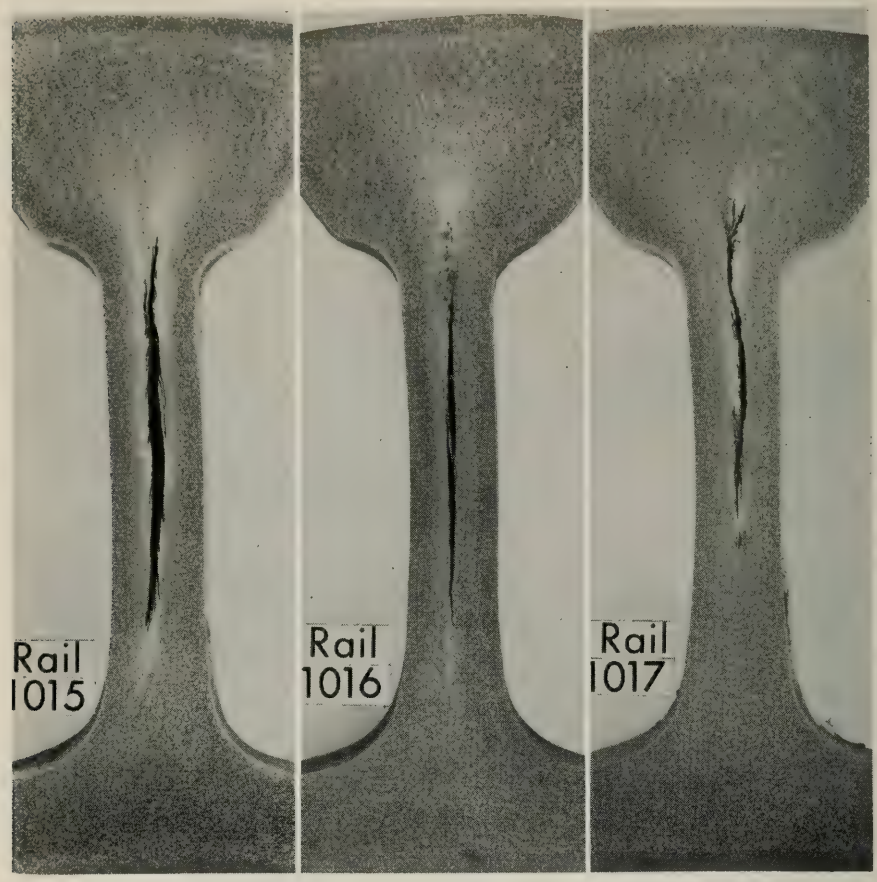

Fig. 8—Vertical split webs from fishtails.

Summary

1. Table 1 lists 17 types of defects found in 25 failed rails. The largest group consisted of 4 piped webs.

2. Eight figures are included, which show the following defects:

   a. Transverse fissure from hot-torn steel.
   b. Transverse fissure from large inclusion.
   c. Vertical split head from fishtail structure.
   d. Fracture from welded engine burn.
   e. Vertical and horizontal split head from fishtail structure.
   f. Vertical split head from porosity in hand-made butt weld.
   g. Corrosion at junction of web and base.
   h. Vertical split webs from fishtails.

Report on Assignment 3

Rail Failures Statistics, Covering (a) All Failures; (b) Transverse Fissures; (c) Performance of Control-Cooled Rail

C. J. Code (chairman, subcommittee), S. H. Barlow, G. V. Begany, Jr., F. W. Biltz, B. Bristow, C. A. Conatser, L. S. Crane, W. J. Cruse, J. K. Gloster, W. H. Hobbs, R. F. Lawson, C. E. Morgan, Embert Osland, G. L. P. Plow, J. G. Roney, S. H. Shepley, H. F. Smith, H. F. Whitmore.

These statistics are based on the rail failures reported to December 31, 1958, and are submitted as information. They include the service and detected failures reported by 59 railroads on all of their main-track mileage, which constitutes the major part of the main track in the United States and Canada. This report was prepared by Kurt Kannowski, metallurgical engineer of the Association of American Railroads, Research Center staff, under the general directon of G. M. Magee, director of engineering research.

The accompanying tables and diagrams indicate the extent of control of the transverse-fissure problem that has been obtained by the use of control-cooled rail and detector-car testing, give data on the quality of each year's rollings for the various mills, and show the types of failures that are occurring on the various railroads as related to the mill producing the rail.

Transverse Fissure Failures

Fig. 1 tells an interesting story about transverse fissures on American railways. The number of transverse fissures that have occurred in service are shown by line "A." These are of particular concern because they may result in train derailments with the attendant risk of property damage or personal injury. The increase in the number of service transverse fissures up to 1928 led to action by the Rail committee to (1) develop detector cars for locating transverse fissures that were developing in rail in track and permit removal of the rail before failures occurred, and (2) establish a cooperative research project with the rail manufacturers to determine means for preventing the development of transverse fissures in rail. This latter investigation resulted in the general adoption of the control-cooling practice for rail in 1937. From 1928 on, the result of detector-car testing is reflected by line "B" showing the number of detected transverse defects that were found and the rails removed from service. It should be understood that not all of these detected transverse defects were transverse fissures, because the detector car can only determine that there is a transverse defect within the rail head but cannot determine the precise cause of the defect. This can only be determined by breaking the rail, and most railroads have not done this because such rails, if unbroken, could be used in yard tracks.

The rapid increase in the number of detected transverse defects each year up to the maximum number of almost 39,000 in 1948 is indeed astonishing. The reasons for the "dip" in the number of detected transverse defects from 1943 to 1948 are not fully understood. There are several factors that could contribute to this, but it is significant to note the general decline in the number of detected transverse defects since 1948. It will be observed that the number has decreased to somewhat under 24,000 in 1958, or 38 percent from the 1948 peak. The credit for this gratifying decrease in the number of detected transverse defects must be given largely to the development and adoption of the control-cooling process for rail.

The sharp increase in the number of detected transverse defects in the years 1947 and 1948 after three years of decline subsequent to 1943 was responsible for the addition of two lines, "C" and "D", to this chart to show the service transverse fissures

and the detected transverse fissures for those roads that broke their detected transverse defects for examination and verification. The detected transverse fissures for these 25 roads did not show the increase for 1947 and 1948 reflected in the detected transverse defects for all roads, but have shown a continuing decline from 1943 to 1953, from which period the number has been relatively uniform. This proved that the increase for 1947 and 1948 in detected transverse defects in line "B" was not due to any fault in the control-cooling procedure. This, together with the fact that several of the 25 roads included have discontinued the practice of breaking rails with detected defects for examination, led to the decision to discontinue lines "C" and "D" as of 1947, and it will be noted that they have not been extended on the figure for 1958. As previously stated, the important line on this figure is "A"—the number of service transverse fissures that have occurred each year. It will be noted that service transverse fissures have declined steadily since 1943, and it is gratifying to note that a further decline, although small, is again reported for 1958. If the number of service transverse fissures had continued to follow the same trend of increase that was indicated prior to 1929 (which would be expected if neither detector car testing nor control-cooling had been inaugurated), it seems likely the number of service transverse fissures that would have occurred in 1958 might have been in excess of 20,000. The actual number that did occur in 1958 was only 600. This figure indeed depicts an interesting story of the effectiveness of the research procedures that were decided upon and put into effect to combat this serious threat to the safety of railway transportation.

Because of the importance of detector-car testing in the control of service rail failures, it has been the practice for the past several years to request data from reporting roads on the number of track miles tested by detector cars. These data are presented herewith, and it is interesting to note that the number of track miles tested by detector cars as reported was somewhat greater in 1958 than the maximum for any preceding year, with fewer railroads reporting.

Year Tested	*No. of Roads Reporting*	*Track Miles Tested by Detector Cars*
1953	59	212,280
1954	56	201,134
1955	56	186,322
1956	50	196,882
1957	57	212,082
1958	54	216,731

It is thus evident that the importance of detector-car testing is recognized by Member Roads and gratifying to note that there is no indicated disposition to reduce the amount of testing even with the reduction that has been effected in service transverse fissure failures.

Mill Performance

The number of service and detected rail failures that occur during the first five years of srevice may be cosnidered a good criterion of mill performance and the quality of rail as manufactured. Fig. 2 shows these failures for 1908 rollings to 1953 rollings, incl. The big decrease occurred in the years prior to 1912, which was a period of changing from the Bessemer to the open-hearth process of manufacture, together with experimentation and improvements in the open-hearth process. During this period there was concern on the part of many railway engineers as to whether open-hearth rail steel would give as good service performance over the years as had been obtained with Bessemer steel. Since 1912 most rail has been manufactured by the open-hearth process, and

the service performance as reflected in Fig. 2 certainly reflects the good judgment shown in changing to the open-hearth process of manufacture.

Although there have been no major changes in the open-hearth method of rail manufacture, there have been many refinements and improvements in control which is reflected in the general decrease in the number of failures during the first five years service from 1917 to date, with the exception of occasional ups and downs for individual years. The record is particularly good from 1937 on when control-cooling was introduced, and is still better from 1948 on when the new rail sections were adopted. It will be noted in Fig. 2 that there was a slight increase in the service and detected failures for the 1953 rollings compared to the 1952 rollings. An explanation of this increase can be found in Fig. 3, showing that Algoma, Carnegie–E. T., Colorado and Dominion mills had a somewhat larger number of failures than usual in the 1953 rolling. In the case of the Algoma mill the major part of the failures occurred in the joint bar area, and the same was true for the Dominion mill. Compound fissures and detail fractures accounted for the increased number of failures in the 1953 rollings of the Carnigie–E. T. and Colorado mills. Since neither of these two types of defects are attributable to any recognized defects in steel quality, it appears that not too much importance should be given to this small increase in number of failures in the 1953 rollings.

Fig. 3 showing the control-cooled-rail failure rates cumulatively for the first 10 years of service between individual mills also affords an opportunity for comparison of mill quality between individual rail producers. It should, of course, be recognized that the service conditions are not necessarily the same for the rail produced by each mill. In general, the performance as indicated is excellent. A comparison of this figure with the corresponding figures in earlier reports shows an outstanding improvement with the new rail sections. The Inland mill discontinued rolling rails after 1957.

To better appreciate the significance of the data shown in Fig. 4 on the failures per 100 track miles for rollings in 1947 to 1956, incl., and particularly as affected by introduction of the new rail sections with the 1948 rollings, a dashed line has been added to the figure to show the number of failures for the first 10 years of service of the old sections for the 10-year period, 1938 to 1947, incl. It is evident from this figure that the mill performance has indeed been excellent for the rollings from 1948 to 1957 and, further, that the change in rail design reflected in the rollings for this period compared with the preceding 10-year period with the old sections has effected a very substantal reduction in the number of failures.

Types of Failures

Table 5 shows the number of failures reported in the last 10 years' rollings classified by type of failure and by mill. Comparison with corresponding data reported last year shows that there has been a reduction of 31 percent in all types of failures, 38 percent in the CF and DF classification and 33 percent in web failures within joint bar limits. This is a large reduction in total failures covering a 10-year period to occur in 1 year's time and is largely due to the large number of failures that had occurred in the 1947 rollings included in last year's table. Last year a comparison was made in the failures of each type for all mills as shown in Table 5 with the corresponding failure rates for the 1938 to 1947 rollings, incl., with the old rail sections. Since last year's report included nine years only with the new sections and one year (1947) with the old sections, the comparison is repeated herewith as a matter of information. The comparison includes control-cooled rail for both the old and new sections. However, failures listed under "new sections" in some instances actually include failures for the "old sections" as a few roads did not change to the new sections.

Type of Failure	*Accumulated Failures* *Old Sections*	*New Sections*
TF—verified by University of Illinois	52	28
CF & DF	4609	5223
VSH	1537	737
HSH	1412	439
Other Head	1401	1919
Broken	1996	297
Web—in joint	9809	3000
Web—other	3918	254
Base	801	721
All types	24635	12829
Failures per 100 track mile years	9.24	4.23

Comparison of the failure rates for the rollings for these two 10-year periods, one before the new rail sections and the other after the new rail sections were introduced, again shows a substantial reduction in vertical split heads, horizontal split heads, broken and, particularly, web failures with the new rail sections. The number of CF's and DF's and other head failures does not reflect a corresponding improvement, but as stated last year this is thought to be due largely to the fact that the figures reported for the new sections still include rollings for some of the old sections in the earlier years which have had a relatively high rate of CF and DF failures. It is believed that a similar comparison made in later years will also reflect a substantial improvement in the CF and DF classification. Also, the total number of failures reported does not take into account the track miles; the reduction in number of failures per 100 track miles from 9.24 for the old sections to 4.23 for the new sections is indeed gratifying.

Table 6 is of interest in comparing the failures by type, by mill and by individual railroads. For Algoma and Dominion rail laid on the Canadian Pacific, it will be noted that the number of vertical split heads, other head failures and web failures within joint bar limits, and for the Algoma mill, base failures, are relatively large in number. Regarding the relative number of failures between Algoma and Dominion rail, C. A. Colpitts, chief engineer of the Canadian Pacific, has commented as follows:

"Our rail is obtained from the Algoma Steel Corporation and from Dominion Steel and Coal Corporation, Ltd. We have in track of the past 10-years' rollings approximately four times as much Algoma rail as Dominion rail. Any comparison we make must of necessity be between these two mills.

"It is our opinion that the statistics as reported do not present a true comparison for the following reasons:

"(1) We have had an extensive program over the past three years of testing in the joint bar area by means of ultrasonic equipment.

"(2) We have also had an extensive program of removing joint bars for visual inspection in the joint bar area, particularly insulated joints. Any failures so detected were classified as service failures.

"As a result of the above programs, we have located many rails with minor defects which under other circumstances might have remained in the track.

"(3) Our rail purchases for the past 10 years have been 100-lb and 130-lb section. The Dominion rail has been 100 lb only, while the Algoma rail has been both 100 lb and 130 lb. The heavier 130-lb section is much less susceptible to failure in the joint bar area, but is used for comparative purposes on the same basis as 100-lb rail.

"(4) The Dominion rail has all been tested by ultrasonic equipment; however, only part of the Algoma rail in track has been tested.

"(5) The Dominion rail is laid in territory with relatively heavy density traffic; on the other hand some Algoma rail is laid where traffic is relatively light. The comparison would be better on a ton-mile basis.

"(6) Almost all the Dominion rail is laid in signal territory, while we have some Algoma rail laid in non-signal territory. We have found that web failures in insulated joints occur more frequently than web failures in non-insulated joints.

"This letter is not to be taken as a comparison of rails between mills, but to point out that we feel the figures as submitted do not always present a true picture."

The foregoing comments serve to illustrate conditions that may exist on individual railroads and which need to be taken into account in interpreting data reported in this table. However, the failure rates shown in the table do serve to direct attention to possible further investigation of what may appear to be an unusually high number of failures from any mill on any railroad or of any particular type of defect. For the Carnegie rollings, the CF and DF classification of failures on the N&W comprise a large proportion of the reported defects. For Colorado rollings, the CF and DF failures on the Union Pacific comprise by far the major portion of reported failures, but it should be noted that there has been a great reduction in this during past years. For example, the UP reported 7644 accumulated failures in Colorado rollings reported in 1955 compared to 2898 in this report for 1958. The Southern Pacific and Union Pacific account for most of the total failures reported in the Colorado rollings. The failures reported in the Inland rollings deserve no special comments, and the same can be said for those reported in Lackawanna rollings. In the Gary rollings the CF and DF failures reported in UP rail are a substantial part of the total failures. In the Steelton rollings the CF and DF failures on the N&W are a substantial part of the total failures, and the same may be said with respect to the L&N reported failures in Tennessee rollings.

In Table 7 are reported the rail failures in the web within the joint bar limits, both service and detected, as found in 1958 on rail of 100 lb and all heavier sections. The failures are shown separately for rail rolled previous to 1937 and for rail rolled in 1937 and thereafter. This table was started because of the increase in the number of this type of defect and the inauguration of the practice on most roads of using defect-detecting instruments, such as the ultrasonic type for locating web failures within joint bar limits. Comparing Table 7 with the corresponding table in last year's report, it will be observed that the number of joints inspected with defect-detecting instruments increased from 8,821,666 in 1957 to 9,747,077 in 1958. Even with this increased amount of testing there were somewhat less detected failures in 1958—6414 compared to 8310 in 1957. Also, the service failures were somewhat higher in 1958, totaling 3304 compared to 3194 in 1957. Web failures within joint bar limits continue to be one of the most important types of rail failures, but fortunately the service failures which do occur do not present nearly as much likelihood of derailments as is presented by service failures where the rail breaks away from the joint bar limits.

All failures in control-cooled rail that are thought to be transverse fissures are sent to the University of Illinois for verification by Professor Ralph E. Cramer as a part of the cooperative rail failure investigation sponsored jointly by the AAR and the AISI. Table 8 shows the results to date of the examination of the submitted failures. First, it is interesting to note that a total of only 234 such failures have been reported in 25 million tons of control-cooled rail rolled from 1935 to 1957, incl. Of these transverse-fissure failures, 81 percent were from hot-torn steel, 4 percent from inclusions and 15 percent from shatter cracks due to improper control-cooling procedure. Five additional failures were reported this year; three of these failures were in Inland rail from hot-torn steel, one in Algoma rail from shatter cracks due to improper cooling, and one in Carnegie rail from an inclusion. Control-cooled rail continues to give a remarkable record of service performance.

TABLE 1 - SERVICE FAILURES FROM TRANSVERSE FISSURES AND DETECTED FAILURES FROM TRANSVERSE DEFECTS BY RAILROADS AND BY YEAR FAILED - ALL ROLLINGS BY ALL PROCESSES

	Service Failures											Detected Failures										
Year Failed	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	Total	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	Total
AT&SF	103	39	52	54	18	19	16	15	7	9	332	1449	1110	1169	1088	970	908	1278	1120	1178	1423	11693
ACL	7	12	9	4	7	4	1	3	2	5	54	919	944	758	741	853	851	836	594	648	565	7709
B&O	100	156	100	91	100	76	59	150	150	102	1084	780	733	745	641	596	696	650	752	909	670	7172
B&OCT	5	1	2	0	2	4	5	12	6	9	46	15	5	2	2	0	3	2	1	2	3	35
Ban Aroos	0	1	0	0	0	1	0	0	0	0	2	16	19	7	11	24	22	16	33	23	18	189
B&LE	3	3	2	2	5	0	1	1	1	0	18	0	0	0	138	36	0	26	27	45	13	285
B&A	-	-	-	-	-	-	-	1	1	1	3	-	-	-	-	-	-	-	52	41	22	115
B&M	16	14	7	24	21	25	25	15	19	17	183	300	375	356	311	292	284	300	282	250	50	2800
CP	131	77	75	47	47	31	39	26	20	16	509	3787	2866	3800	4251	1504	1805	1375	1258	976	1210	22832
C. of Ga.	18	17	24	14	12	10	4	5	0	0	104	275	274	243	301	0	367	570	426	694	685	3835
C&O (Sys.)	37	22	29	43	21	16	39	19	52	30	308	850	514	643	684	683	562	383	523	200	497	5539
C&EI	41	17	15	21	18	19	14	14	1	0	160	320	265	212	97	150	206	152	136	253	154	1945
C&NW	118	84	85	74	72	62	73	38	38	37	681	1159	816	1216	817	836	861	778	807	675	838	8805
CB&Q	65	59	59	28	23	17	12	8	7	5	283	975	465	679	687	463	940	922	795	825	293	7044
CI&L	0	4	4	5	2	5	0	0	0	4	24	77	151	80	58	58	75	81	124	66	69	839
CMStP&P	61	48	42	45	44	30	21	21	11	16	339	1080	675	763	733	982	928	810	893	864	749	8477
CRI&P	47	48	56	46	49	27	22	21	13	8	337	620	445	369	537	322	412	528	744	1076	228	5281
C&S	5	2	0	4	-	2	0	1	0	1	15	72	164	55	182	-	308	133	140	124	114	1292
D&H	12	6	10	10	5	0	0	0	0	0	43	508	306	430	367	327	314	97	219	121	180	2869
DL&W	8	7	3	5	-	-	-	-	-	-	23	186	270	225	257	-	-	-	-	-	-	938
D&RGW	15	16	14	-	-	6	3	4	0	5	63	373	741	645	-	-	455	514	502	436	310	3976
Erie	43	24	19	20	19	9	10	15	3	10	172	570	543	475	459	435	369	270	317	275	180	3993
FEC	39	27	1	7	0	0	4	0	0	0	78	243	26	13	30	94	175	129	73	87	61	931
GTW	19	11	9	7	16	6	4	9	1	8	90	123	118	85	71	96	74	82	67	99	117	932
GN	+102	85	94	63	47	45	42	29	24	26	557	936	1167	1069	1525	932	1163	914	1362	1262	583	10913
IC (Sys.)	69	53	55	28	33	25	10	15	5	6	299	1284	1296	1226	1279	1088	908	830	826	782	593	10112
JCL	37	48	14	14	11	9	7	7	5	9	161	0	0	0	56	15	56	83	75	71	56	412
KCS	8	4	6	6	0	8	1	2	10	2	47	73	100	93	94	89	58	47	54	37	42	687
L&HR	0	0	1	1	0	0	0	0	0	0	2	0	0	11	8	8	6	6	1	3	4	47
L&NE	0	0	0	1	0	2	0	0	2	1	6	4	12	12	12	0	14	15	0	15	8	92
LV	6	14	12	20	8	2	8	2	8	3	83	126	87	163	105	108	123	94	147	72	57	1082

TABLE 1 (Continued)

	Service Failures											Detected Failures										
Year Failed	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	Total	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	Total
LI	0	0	0	0	0	0	12	-	9	4	25	25	26	18	25	15	14	49	-	13	19	204
L&N	60	48	63	40	40	29	29	27	30	24	390	864	743	843	926	711	592	696	589	606	760	7330
Me. Cent.	7	6	2	3	2	-	1	8	5	1	35	74	130	89	55	46	-	36	36	43	45	554
MStP&SStM	17	11	11	6	0	0	10	1	1	2	59	73	104	116	138	81	632	48	68	67	59	1386
MKT	24	16	19	13	14	8	8	18	3	1	124	532	359	290	162	270	259	212	245	187	153	2669
MP Lines	24	*57	72	51	42	23	11	6	11	16	313	518	1479	1308	1267	981	783	725	591	574	608	8857
NC&StL	9	7	6	5	4	1	1	2	0	**	35	59	45	43	43	11	3	6	10	7	**	227
NYC (Sys.)#	165	154	177	130	155	114	59	95	63	66	1178	1508	1306	1344	1284	1151	1612	508	956	1152	841	11662
NYC&StL	21	19	16	13	10	9	7	6	4	7	112	118	106	84	77	60	54	39	41	32	11	622
NYNH&H	2	3	1	0	2	4	5	4	2	1	24	79	116	77	48	73	56	62	81	118	40	750
NYO&W	12	21	25	10	8	6	1	3	***	***	86	0	11	20	86	110	182	28	37	***	***	474
N&W	3	3	1	3	2	4	3	7	3	3	32	84	130	124	157	113	135	103	166	403	248	1663
NP	90	73	11	1	0	0	1	9	4	7	196	473	347	377	372	417	429	339	436	381	373	3944
PRR ++	430	92	103	85	122	76	67	129	95	51	1250	1166	1876	1844	1322	1792	1574	1600	1880	1783	1810	16847
P&LE	0	0	1	0	0	0	0	0	0	0	1	22	29	12	20	26	22	26	10	9	7	183
Reading	0	0	0	0	0	0	0	0	0	5	5	404	241	451	205	396	460	271	290	274	299	3291
RF&P	6	1	0	0	1	0	1	0	0	0	9	195	172	128	64	55	25	24	18	18	23	722
Rutland	0	0	4	0	2	2	0	3	4	2	17	0	0	28	0	0	0	0	0	0	0	28
StL-SF	52	17	16	0	3	5	6	7	3	1	110	639	515	377	410	398	346	309	568	1674	2145	7318
SAL	18	22	7	14	7	12	9	6	10	17	122	299	454	324	318	344	344	300	253	259	257	3152
SP	98	68	75	76	69	63	55	38	23	13	578	1012	952	960	970	1005	728	794	934	833	623	8811
Southern	98	98	106	70	63	41	32	20	24	36	588	2009	1927	1682	1490	1622	2157	1732	1442	1263	1579	16903
T&NO	99	90	88	79	55	28	16	1	0	4	460	1006	958	788	749	606	708	456	463	353	470	6557
T&P	22	16	8	7	5	6	3	2	5	4	78	173	152	114	90	70	115	58	57	49	35	913
UP	19	23	13	15	13	18	10	7	1	5	124	3613	3429	4142	4157	4632	5003	4074	4044	3113	3421	39628
Virginian	1	0	0	1	0	0	0	3	7	0	12	24	60	73	45	39	41	57	66	84	197	686
W. Md.	3	16	15	14	8	4	0	2	0	0	62	302	138	133	156	153	59	105	84	35	33	1198
W&LE	3	7	-	-	-	-	-	-	-	-	10	5	11	-	-	-	-	-	-	-	-	16
ALL ROADS	2398	1767	1639	1320	1207	913	767	837	693	600	12141	32396	30303	31333	30178	26138	29376	24578	25718	25439	24848	279307

*Includes all transverse defects
***Ceased Operations 3-29-57
**Merged with the L&N Railroad
-No report received

#Includes IHB failures
##Including LI RR and PRSL 1940 to 1948 inclusive
+ Includes engine burn fractures

TABLE 2 - TONS OF RAILS AND TRACK MILES OF EACH YEAR'S ROLLINGS 1948 - 1957 INCL., REPORTED BY 57 RAILROADS.

Year Rolled	OH CONTROL COOLED ONLY	
	TONS	TRACK MILES
1948	1,407,756	6,601.31
1949	1,254,278	5,966.41
1950	1,311,038	6,335.78
1951	1,229,261	5,908.58
1952	987,006	4,796.63
1953	1,207,782	5,683.69
1954	823,831	3,833.60
1955	883,125	4,085.60
1956	865,017	4,024.40
1957	814,723	3,480.30
TOTAL	10,783,817	50,716.30

TABLE 3 - SERVICE AND DETECTED FAILURES OF ALL TYPES EXCEPT ENGINE BURN FAILURES ACCUMULATED FROM DATE ROLLED TO DECEMBER 31, 1957 PER 100 AVERAGE TRACK MILES, CONTROL COOLED RAIL ONLY, IN ALL ROLLINGS, FROM ALL MILLS.

Year Rolled	YEARS OF SERVICE									
	1	2	3	4	5	6	7	8	9	10
1948	0.7	1.6	3.6	7.5	11.5	19.1	26.4	35.6	45.4	55.4
1949	1.7	4.1	7.2	10.0	15.8	21.7	28.8	36.7	45.7	
1950	3.1	6.0	9.6	14.1	19.6	25.9	35.8	45.6		
1951	2.0	3.4	5.0	10.4	16.3	21.7	27.5			
1952	2.0	2.8	4.3	7.9	13.2	18.7				
1953	0.8	2.0	4.0	9.2	15.6					
1954	0.5	1.3	3.5	6.1						
1955	0.7	1.5	2.3							
1956	0.4	1.3								
1957	0.5									

TABLE [illegible] TRACK MILES AND 1958 FAILURES, ALL [illegible], IN ROLLINGS [illegible] TO [illegible], INCL.
OPEN-HEARTH CONTROL COOLED RAIL ONLY

ROAD	TRACK MILES BY MILL										1958 FAILURES	
	ALG	CARN	COLO	DOM	GARY	INLD	LACKA	STLTN	TENN	TOTAL	EBFs EXCL	EBFs ONLY
AT&SF			[illegible]		1061	258				3209	27	5
ACL		[illegible]						[illegible]	1017	[illegible]	[illegible]	
B&O		549			597		79	[illegible]		1671	18	8
B&OCT						37				37	2	
[illegible] Aroos								82		82	2	
[illegible]		60								60	1	
Bes & Alb							78			78		
B&M		23					20	62		105		
CP	3702			870			60			4632	980	1
C. of Ga.									283	283		
C&O (Sys.)	21	[illegible]			890	[illegible]	267	[illegible]		[illegible]	[illegible]	1
C&EI					107	11				118	4	
CNW					508	146	159			813	2	
CB&Q			962		866	177				2005	4	1
CI&L					94	47				141	1	
CMStP&P					1066	332				1398	3	
CRI&P			99		794	253				1146	5	
CCC&StL -P&E					412	63	[illegible]			480	14	
C&S			147							147	2	9
D&H								197		197	6	
D&RGW			329							329	13	
[illegible]		359			319	25	[illegible]			782	9	4
FEC		28						44	217	289		
GTW					178	59	62			299	5	
GN			588		707	294	233	[illegible]		1827	70	
IC					1180	527			307	2014	12	1
JCL								146		146	2	
KCS					212	23			12	247		
L&HR								24		24		
L&NE								[illegible]		[illegible]		
LV							294			294		
LI										0		
L&N					51				1813	[illegible]	35	4
Me. Cent.							106	3		106	1	
MStP&SStM	5				261	263	[illegible]			[illegible]	15	
MKT			59		133	26				218	2	
MP Lines			1037		653	154			187	2031	2	
NYC-E					52	21	753			826	86	5
NYC-W					389	25				414	24	1
NYC&StL		74			373	[illegible]	179			691	13	
NYNH&H		74						224		298	4	7
N&W		802						[illegible]		1046	251	27
NP			489		360	95	154			1098	15	1
PRR		605			248	64		[illegible]		1453	42	
P&LE		143								143	5	1
Reading								403		403		
RF&P								172		172		
Rutland										0		
St. L-SF						10			798	808		
SAL		3						587	[illegible]	1257	3	2
SP			2700							2700	269	21
Southern					16	15		591	1313	1935	23	2
T&NO			[illegible]						143	789	84	
T&P			[illegible]						168	414		
UP			2075		778	115				2968	863	8
Va.		109						142		251	10	
W. Md.		136						[illegible]		361		
TOTAL	3728	3037	[illegible]	870	12105	3725	2573	[illegible]	[illegible]	[illegible]	2972	112

NOTE: The following railroads did not report in 1959 and were omitted from this table: DL&W and IHB.
The NC&StL merged with the L&N Railroad.

TABLE 5 - ACCUMULATED FAILURES AND FAILURES PER 100 TRACK MILES, IN ROLLINGS 1948 TO 1957, INCLUSIVE FROM DATE ROLLED TO DECEMBER 31, 1958, SERVICE AND DETECTED, BY MILL AND TYPE OF FAILURE

OH CONTROL COOLED RAIL ONLY

MILL	ACCUMULATED FAILURES TO DEC. 31, 1958 (EXCL. EBFs)									ALL TYPES	TRACK MILES	TRACK MILE YEARS	FAILURES PER 100 TRACK MI. YEARS
	TF VER U of I	CF & DF	VSH	HSH	OTHER HEAD	BROKEN	WEB IN JT.	WEB OTHER	BASE				
ALGOMA	12	14	351	8	300	67	923	34	600	2309	3728	22398	10.31
CARNEGIE (ET)	0	673	7	19	81	8	109	9	10	916	3337	21065	4.35
COLORADO	0	3340	102	312	893	45	498	326	12	5528	11923	69758	7.92
DOMINION	0	2	73	2	57	10	777	8	33	962	868	5034	19.11
GARY	0	487	69	20	327	82	174	27	17	1203	12268	73992	1.63
INLAND	2	170	25	10	34	22	44	15	4	326	3837	22201	1.47
LACKAWANNA	3	86	49	9	112	23	254	13	37	586	2711	16951	3.46
STEELTON	11	366	30	21	54	20	71	10	3	586	5373	32300	1.81
TENNESSEE	0	85	31	38	61	20	150	23	5	413	6996	39562	1.04
ALL MILLS	28	5223	737	439	1919	297	3000	465	721	12829	51041	303261	
FAILURES PER 100 TRACK MILE YEARS	.01	1.72	.24	.14	.63	.10	.99	.15	.24	4.23			

Definition of symbols:

TF - Transverse Fissure
CF - Compound Fissure
DF - Detail Fracture
VSH - Vertical Split Head
HSH - Horizontal Split Head
EBF - Engine Burn Fracture

TABLE 6 - ACCUMULATED FAILURES OF ALL TYPES FOR OH CONTROL COOLED RAIL, ONLY IN ROLLING 1948 - 1957, INCL., ACCUMULATED TO DECEMBER 31, 1958 SERVICE AND DETECTED, SEGREGATED BY ROADS AND MILLS.

ROADS	TF Ver U of I	CF & DF	VSH	HSH	Other Head	Broken	Web In. Jt.	Web Other	Base	FAILURE TOTALS EBFs Excl. Accum. Total	FAILURE TOTALS EBFs Excl. 1958	FAILURE TOTALS EBFs Only Accum. Total	FAILURE TOTALS EBFs Only 1958
ALGOMA													
CP	12	14	351	8	300	67	923	34	300	2309	604	1	1
TOTAL	12	14	351	8	300	67	923	34	300	2309	604	1	1
CARNEGIE													
B&O	0	9	1	1	7	0	11	0	2	31	7	6	2
B&LE	0	0	0	1	0	0	0	0	0	1	1	0	0
B&M	0	0	0	0	0	1	0	0	0	1	0	0	0
C&O (Sys.)	0	16	0	0	0	0	14	0	0	30	5	1	0
Erie	0	0	0	1	1	1	6	0	0	9	0	9	2
NYC&STL	0	2	0	3	13	1	20	1	0	40	2	0	0
NYNH&H	0	4	0	0	1	0	6	0	0	11	3	0	0
N&W	0	615	3	6	51	2	36	4	8	725	188	49	22
PRR	0	23	2	5	8	0	9	0	0	47	16	70	0
P&LE	0	0	0	1	0	0	6	0	0	7	5	5	1
Va.	0	4	0	1	0	2	1	3	0	11	2	0	0
W. Md.	0	0	1	0	0	1	0	1	0	3	0	0	0
TOTAL	0	673	7	19	81	8	109	9	10	916	235	140	27
COLORADO													
AT&SF	0	19	12	3	13	0	36	5	0	88	20	4	4
CB&Q	0	4	0	1	2	0	1	0	0	8	1	2	1
C&S	0	0	1	1	0	0	0	0	0	2	2	21	9
D&RGW	0	34	1	0	0	0	2	0	0	37	13	0	0
GN	0	3	4	1	6	0	42	0	0	56	39	0	0
MP Lines	0	2	4	3	3	0	3	0	0	15	0	8	0
NP	0	0	3	0	48	4	5	1	0	61	7	2	0
SP	0	375	55	219	220	36	352	254	9	1520	269	184	21
T&NO	0	5	4	15	6	3	29	19	0	81	36	1	0
UP	0	2898	18	69	595	2	28	17	3	3660	728	33	6
TOTAL	0	3340	102	312	893	45	498	326	12	5328	1115	255	41

TABLE 6 - CONTINUED

ROADS	TF Ver U of I	CF & DF	VSH	HSH	Other Head	Broken	Web In. Jt.	Web Other	Base	FAILURE TOTALS EBFs Excl. Accum. Total	FAILURE TOTALS EBFs Excl. 1958	FAILURE TOTALS EBFs Only Accum. Total	FAILURE TOTALS EBFs Only 1958
INLAND													
AT&SF	0	0	0	0	0	0	1	3	0	4	4	0	0
B&OCT	0	0	0	1	0	1	1	2	0	5	2	1	0
C&O (Sys.)	1	24	4	1	2	3	5	3	1	44	7	9	1
C&NW	0	0	3	1	0	0	0	1	0	5	1	0	0
CB&Q	0	3	0	0	2	0	0	0	0	5	2	0	0
CI&L	0	0	0	0	1	0	0	0	0	1	1	0	0
CMStP&P	0	0	1	1	0	0	0	0	0	2	0	0	0
CRI&P	0	0	0	1	1	2	0	0	0	4	1	0	0
Erie	0	0	2	0	0	0	0	0	0	2	2	0	0
GTW	0	0	0	0	0	1	2	0	0	3	0	0	0
CN	0	25	5	1	16	0	12	0	2	61	12	0	0
IC	0	1	2	0	3	0	7	0	1	14	2	1	1
MStP&SStM	0	1	5	0	0	12	9	2	0	29	13	0	0
MP Lines	0	1	1	0	0	0	1	0	0	3	0	0	0
NYC&StL	1	0	1	1	0	2	1	0	0	6	2	0	0
NP	0	0	0	0	2	1	2	0	0	5	2	0	0
PRR	0	0	0	0	0	0	1	0	0	1	0	0	0
StL-SF	0	0	0	1	0	0	0	0	0	1	0	0	0
UP	0	115	1	2	7	0	2	4	0	131	15	0	0
TOTAL	2	170	25	10	34	22	44	15	4	326	56	11	2
LACKAWANNA													
B&O	0	1	3	0	3	0	4	3	0	14	0	6	0
B&M	1	12	0	0	3	0	0	0	0	16	0	0	0
CP	0	0	3	0	17	0	37	0	13	70	20	0	0
C&O (Sys.)	2	40	0	2	2	0	18	2	0	66	4	2	0
C&NW	0	0	0	1	3	4	0	6	2	16	0	0	0
GTW	0	0	32	1	0	6	1	0	3	43	0	0	0
GN	0	9	2	1	40	0	1	0	1	54	0	0	0
LV	0	1	0	0	0	0	0	0	0	1	0	0	0
Me. Cent.	0	0	0	0	0	0	1	0	0	1	1	0	0
MStP&SStM	0	0	0	0	0	2	0	1	3	6	1	0	0
NYC-E	0	16	9	3	40	2	156	1	13	240	85	13	5
NYC&StL	0	7	0	1	3	8	30	0	0	49	5	0	0
NP	0	0	0	0	1	1	6	0	2	10	2	0	0
TOTAL	3	86	49	9	112	23	254	13	37	586	118	21	5

TABLE 6 - CONTINUED

ROADS	TF Ver U of I	CF & DF	VSH	HSH	Other Head	Broken	Web In. Jt.	Web Other	Base	FAILURE TOTALS EBFs Excl. Accum. Total	EBFs Excl. 1958	EBFs Only Accum. Total	EBFs Only 1958
DOMINION													
CP	0	2	73	2	57	10	777	8	33	962	356	0	0
TOTAL	0	2	73	2	57	10	777	8	33	962	356	0	0
GARY													
AT&SF	0	0	0	0	2	0	5	1	0	8	3	2	1
B&O	0	1	5	0	2	1	9	0	0	18	2	31	0
C&O (Sys.)	0	61	9	2	3	3	15	1	0	94	19	7	3
C&EI	0	1	2	0	6	0	19	0	0	28	4	0	0
C&NW	0	1	0	0	6	0	4	0	2	13	1	0	0
CB&Q	0	0	1	2	3	0	3	0	0	9	1	0	0
CMStP&P	0	5	5	0	0	5	2	0	0	17	3	0	0
CRI&P	0	0	2	1	2	6	4	1	2	18	4	4	0
CCC&StL	0	4	3	0	15	0	15	6	0	43	14	8	0
Erie	0	0	0	0	0	0	1	0	0	1	1	2	2
GTW	0	0	13	1	2	11	1	0	1	29	5	0	0
GN	0	88	3	3	93	17	11	1	1	217	19	0	0
IC	0	13	4	0	5	2	11	3	1	39	10	0	0
KCS	0	0	2	0	0	0	0	0	0	2	0	0	0
L&N	0	0	0	0	0	0	1	0	0	1	0	0	0
MStP&SStM	0	0	4	0	1	7	1	0	5	18	1	0	0
MKT	0	0	1	0	0	1	0	0	0	2	2	0	0
MP Lines	0	0	0	1	1	0	2	1	1	6	1	1	0
NYC-E	0	1	0	0	1	0	0	0	0	2	1	0	0
NYC-W	0	3	4	0	11	16	39	3	0	76	24	21	1
NYC&StL	0	7	0	2	4	5	14	1	0	33	4	0	0
NP	0	0	3	1	11	8	10	2	0	35	4	5	1
PRR	0	3	1	1	0	0	5	1	0	11	4	4	0
UP	0	299	7	6	159	0	2	6	4	483	120	17	2
TOTAL	0	487	69	20	327	82	174	27	17	1203	247	102	10

TABLE 6 - CONTINUED

ROADS	TF Ver U of I	CF & DF	VSH	HSH	Other Head	Broken	Web In. Jt.	Web Other	Base	FAILURE TOTALS EBFs Excl. Accum. Total	EBFs Excl. 1958	EBFs Only Accum. Total	EBFs Only 1958
STEELTON													
ACL	0	0	0	1	0	0	29	0	1	31	0	1	0
B&O	8	10	7	4	11	0	5	0	1	46	9	26	6
Ban Aroos	0	0	2	1	6	0	1	0	0	10	2	0	0
B&M	0	1	0	0	5	1	1	1	0	9	0	5	0
C&O (Sys.)	1	33	1	1	6	0	1	0	0	43	0	0	0
D&H	0	11	1	2	1	0	0	1	0	16	6	1	0
FEC	0	1	0	0	0	0	0	0	0	1	0	1	0
JCL	0	0	2	0	0	0	2	2	0	6	2	0	0
NYNH&H	0	1	3	3	2	0	2	0	0	11	1	22	7
N&W	1	221	2	4	13	1	16	0	1	259	63	17	5
PRR	0	57	3	2	7	0	9	0	0	78	22	30	0
Reading	0	2	0	0	0	2	2	0	0	6	0	0	0
RF&P	1	1	0	0	3	0	0	0	0	5	0	0	0
SAL	0	2	6	1	0	1	0	0	0	10	2	1	1
Southern	0	0	2	0	0	2	3	0	0	7	3	0	0
Va.	0	26	0	1	0	13	0	6	0	46	8	0	0
W. Md.	0	0	1	1	0	0	0	0	0	2	0	1	0
TOTAL	11	366	30	21	54	20	71	10	3	586	118	105	19
TENNESSEE													
ACL	0	0	1	2	3	1	53	5	1	66	5	4	0
C. of Ga.	0	0	3	0	1	2	6	0	1	13	0	7	0
FEC	0	5	0	1	0	1	0	1	0	8	0	5	0
IC	0	2	1	2	6	0	0	0	0	11	0	0	0
L&N	0	72	14	23	20	5	24	6	3	167	38	14	4
MP Lines	0	0	1	0	0	0	0	0	0	1	1	1	0
St. L-SF	0	0	3	4	1	4	3	1	0	16	0	0	0
SAL	0	0	2	1	1	1	0	0	0	5	1	1	1
Southern	0	6	6	4	28	6	20	0	0	70	20	23	2
T&NO	0	0	0	1	1	0	44	10	0	56	48	0	0
TOTAL	0	85	31	38	61	20	150	23	5	413	113	55	7
ALL MILLS	28	5223	737	439	1919	297	3000	465	721	12829	2972	690	112

TABLE 7
RAIL FAILURES IN THE WEB WITHIN THE JOINT BAR LIMITS FOUND IN 1958
ON RAIL OF 100 LB. AND ALL HEAVIER SECTIONS

Railroad	Rail Rolled Previous to 1937				Rail Rolled in 1937 and After				Joints Inspected with Defect Detecting Instruments
	Detected Failures		Service Failures		Detected Failures		Service Failures		
	Bolt Hole	Other	Bolt Hole	Other	Bolt Hole	Other	Bolt Hole	Other	
AT&SF	32	48	9	0	217	211	102	0	2,194,564
ACL	3	36	111	105	19	378	15	14	42,585
B&O	26	0	1054	76	1	0	52	22	0
B&OCT	0	0	19	6	0	1	1	2	-
Ban & Aroos	1	0	3	1	2	0	1	2	-
Bos & Alb	4	10	0	0	8	17	3	0	10,950
B&M	31	22	22	27	2	6	2	0	380,939
CP	116	81	45	9	525	636	214	294	1,397,495
C&O (Sys.)	22	38	21	9	3	9	8	10	22,599
C&EI	0	0	29	0	0	0	20	0	-
C&NW	48	133	252	213	9	124	71	95	97,696
CB&Q	3	0	76	4	104	114	87	82	159,181
CI&L	5	0	40	7	0	0	1	4	9,400
CMStP&P	435	6	174	5	12	1	24	1	433,750
CRI&P	20	2	134	128	8	0	74	88	-
CCC&StL	5	22	19	30	49	31	9	25	223,148
C&S	1	0	1	0	0	0	2	0	0
D&H	0	0	20	6	0	0	4	2	-
D&RGW	0	0	10	8	0	0	6	15	0
Erie	127	60	34	7	8	41	7	13	47,827
GTW	22	21	29	4	9	4	42	3	26,042
GN	138	0	68	0	48	1	136	0	175,348
IC	3	1	13	4	21	19	49	13	71,426
JCL	0	0	61	37	4	6	0	0	9,687
KCS	1	0	0	0	0	0	1	0	-
L&HR	0	0	3	0	0	0	4	0	0
L&NE	8	0	2	0	3	0	1	0	-
LV	107	14	37	0	0	0	2	0	70,681

TABLE 7 (Cont.)
RAIL FAILURES IN THE WEB WITHIN THE JOINT BAR LIMITS FOUND IN 1958
ON RAIL OF 100 LB. AND ALL HEAVIER SECTIONS

Railroad	Rail Rolled Previous to 1937				Rail Rolled in 1937 and After				Joints Inspected with Defect Detecting Instruments
	Detected Failures		Service Failures		Detected Failures		Service Failures		
	Bolt Hole	Other	Bolt Hole	Other	Bolt Hole	Other	Bolt Hole	Other	
LI	30	3	0	0	0	0	0	0	0
L&N	7	46	63	0	8	11	49	4	-
Me. Cent.	10	20	3	0	1	4	1	0	-
MStP&SStM	116	0	59	0	0	0	0	0	327,500
MKT	0	0	0	0	0	0	6	6	0
MP Lines	2	3	8	8	17	175	15	15	30,374
NYC - E	106	18	85	35	585	299	180	76	230,632
NYC - W	79	47	70	24	166	15	47	65	-
NYC&StL	0	0	26	0	14	4	260	0	14
NYNH&H	3	2	449	25	0	0	99	27	-
N&W	4	34	2	0	0	21	5	2	10,888
NP	4	0	219	8	3	0	217	21	-
PRR	1710	444	1540	291	603	344	179	70	1,464,319
P&LE	0	0	0	0	15	1	11	1	6,535
Reading	14	0	4	0	2	0	0	0	-
RF&P	0	0	0	0	2	15	0	0	6,938
StL - SF	116	54	29	5	15	258	79	6	72,717
SAL	0	0	14	0	0	0	17	1	0
Southern	45	332	0	0	14	169	0	0	67,256
SP	14	9	1	22	10	142	98	64*	195,493
T&NO	54	32	3	23	261	29	4	19	122,183
T&P	246	31	4	0	125	27	8	2	185,610
UP	75	63	9	1	287	117	18	5	1,653,300
Va.	10	2	0	2	3	1	0	0	-
W. Md.	0	0	0	0	0	0	2	2	-
Totals	3803	1634	4874	1130	3183	3231	2233	1071	9,747,077

*Includes all service head and web separation failures, records do not indicate whether or not these failures occurred within joint bar limits.

TABLE 8 - ACCUMULATED TRANSVERSE FISSURE FAILURES IN CONTROL COOLED RAIL AS VERIFIED BY LABORATORY INVESTIGATION, BY ROAD, MILL AND YEAR ROLLED TO OCTOBER 1, 1959

Roads	Mills	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	Total
CN	Algoma												1 (a)										1
CP	Algoma					1 (b)	1 (a)	2 (b)		1 (a)	1 (a)		2 (b)	1(a)1(b)	1 (b)	6 (b)	6 (b)						23
Mich. C.	Algoma					1 (b)			1 (b)														2
PM	Algoma						1 (a)																1
NYNH&H	Carnegie (ET)			1 (c)																			1
N&W	Carnegie (ET)					1 (a)				1 (c)								2 (c)					4
AT&SF	Colorado					1 (c)																	1
CB&Q	Colorado							1 (c)															1
CN	Dominion						1 (b)																1
AT&SF	Gary			1 (b)																			1
C&NW	Gary		3 (b)	2 (b)																			5
CB&Q	Gary		3 (b)																				3
GN	Gary		1 (b)																				1
NYC	Gary				1 (b)																		1
Wabash	Gary			1 (b)																			1
AT&SF	Inland							2 (a)															2
CB&Q	Inland									1 (a)	3 (a)												4
C&O	Inland	1 (a)		3 (a)				5 (a)			1 (a)	1 (a)			1 (a)			1 (a)	2 (a)		1 (a)	1 (a)	18
CMStP&P	Inland										2 (a)												2
CRI&P	Inland												1 (a)										1
NYC&StL	Inland																		1 (a)				1
MKT	Inland										1 (b)		1 (a)										2
UP	Inland					3 (a)	3 (a)																6
B&M	Lackawanna										1 (a)												1
C&O	Lackawanna															1 (a)	1 (a)						2
LV	Lackawanna								3 (a)	1 (a)													4
NYC	Lackawanna								1 (a)	1 (a)	2 (a)												4
NYC&StL	Lackawanna								2 (a)		3 (a)			3 (a)	1 (a)								9
AT&SF	Steelton			3 (a)																			3
B&O	Steelton						1 (a)	1 (a)	3 (a)	1 (a)	1 (a)	1 (a)	1 (a)		1 (a)		3 (a)	3 (a)	4 (a)				20
B&M	Steelton						2 (a)		1 (a)														3
C of NJ	Steelton							1 (a)		1 (a)													2
C&O	Steelton	5 (a)		1 (a)	4 (a)		3 (a)						1 (a)			1 (a)							15
D&H	Steelton				1 (a)	2 (a)	1 (c)		1 (a)	1 (a)													6
MP	Steelton			1 (a)																			1
N&W	Steelton					1 (a)	4 (a)		5 (a)					2 (a)			1 (a)						16
NYNH&H	Steelton			3 (a)		2 (a)	1 (a)		1 (a)	2 (a)													9
PRR	Steelton		2 (a)																				2
RF&P	Steelton			1 (a)			1 (a)								2 (a)								4
SAL	Steelton							2 (a)		1 (a)													3
So. Ry.	Steelton							1 (a)		2 (a)													3
SP	Steelton		18 (a)	3 (a)	6 (a)	5 (a)	1 (a)																33
T&NO	Steelton		2 (a)	1 (a)																			3
Va.	Steelton						2 (a)	1 (a)	1 (a)														4
C. of Ga.	Tennessee									1 (c)													1
IC	Tennessee									1 (c)													1
L&N	Tennessee							1 (c)															1
SP	Tennessee		1 (b)																				1
TOTAL		6	30	21	12	17	22	18	22	15	15	2	7	7	6	8	11	6	7	0	1	1	234

TABLE 8 (Cont.) - SUMMARY BY MILLS

Mills	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	Total
Algoma					2	2	2	1	1	1		3	2	1	6	6	1					28
Carnegie (ET)			1		1				1								1					4
Colorado	*				1		1															2
Dominion						1																1
Gary		7	4	1																		12
Inland	1		3		3	3	8		1	7	1	2		1			1	3		1	1	36
Lackawanna								6	2	6			3	1	1	1						20
Steelton	5	22	13	11	10	16	6	15	8	1	1	2	2	3	1	4	3	4				127
Tennessee		1					1		2													4
TOTAL	6	30	21	12	17	22	18	22	15	15	2	7	7	6	8	11	6	7	0	1	1	234

Note: (a) TRANSVERSE FISSURE from hot torn steel. (b) TRANSVERSE FISSURE from shatter cracks due to improper cooling. (c) TRANSVERSE FISSURE from inclusion. Summary - 36 T. F.'s from shatter cracks, 10 T. F.'s from inclusions, 188 T. F.'s from hot torn steel.

*No cc rail rolled.

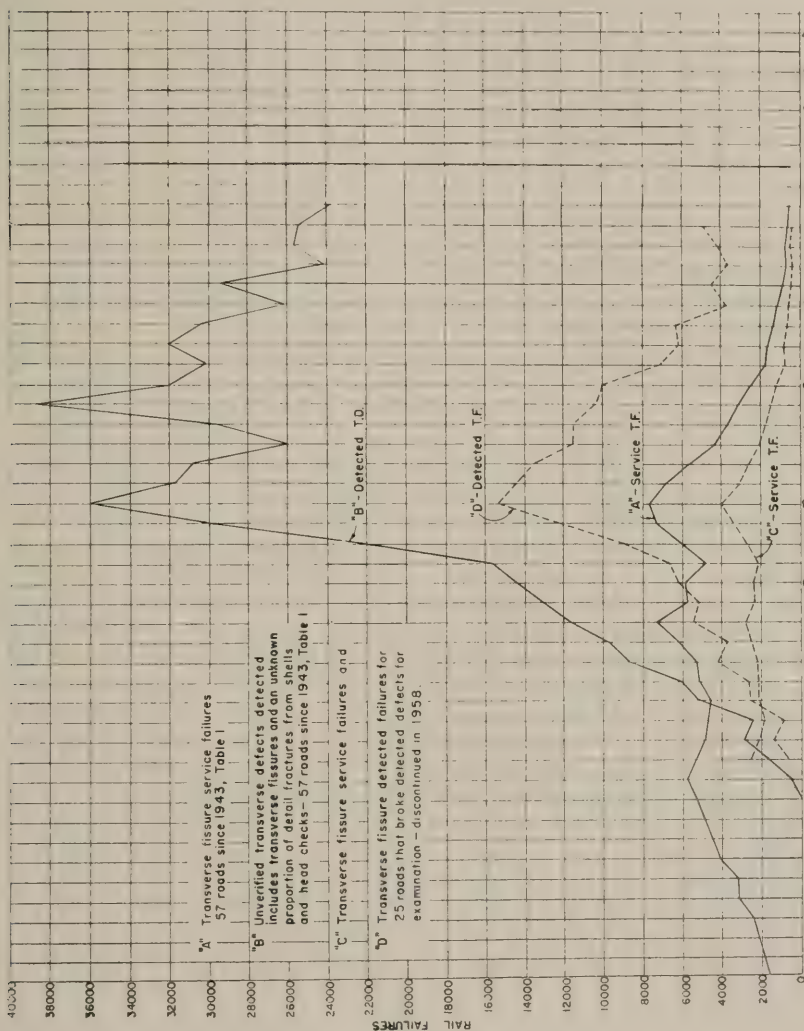

FIG. I - ANNUAL SERVICE RAIL FAILURES DUE TO TRANSVERSE FISSURES AND TO DETECTED TRANSVERSE DEFECTS AS REPORTED BY ALL RAIL ROADS.

FIG. 2- SERVICE AND DETECTED FAILURES IN UNITED STATES AND CANADA

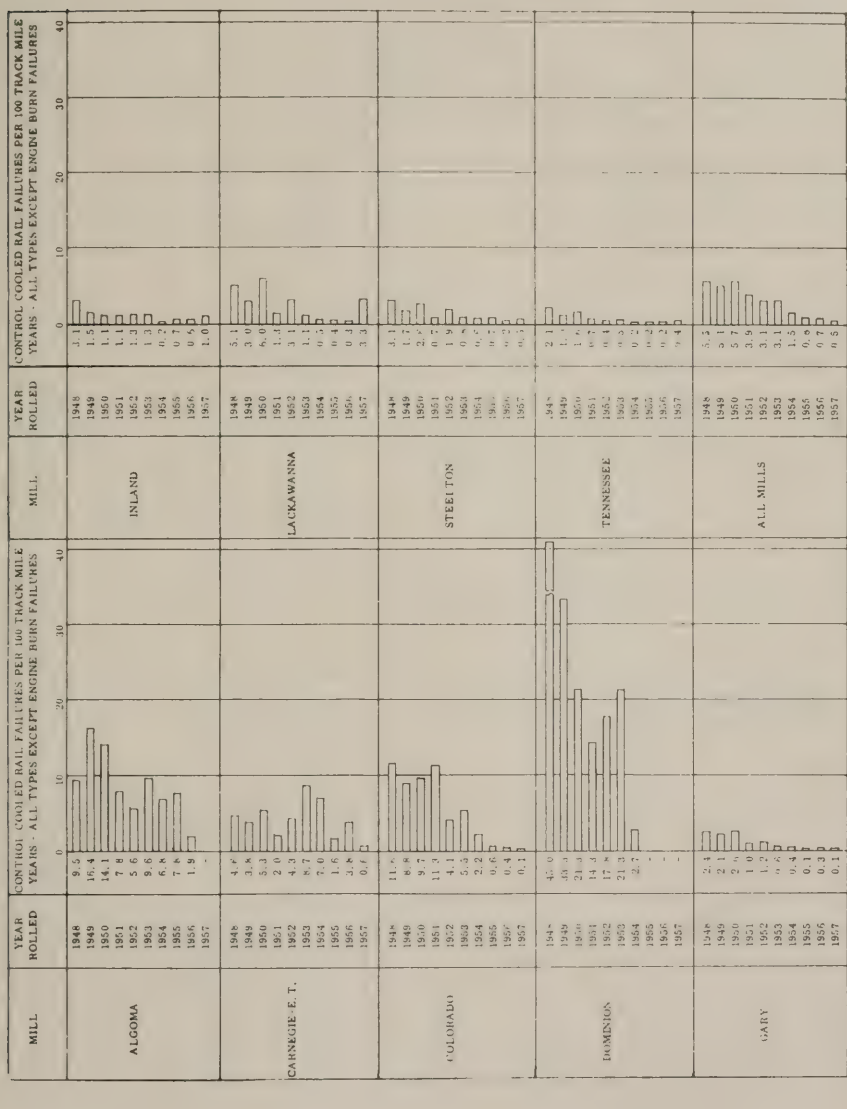

FIG. 3 - CONTROL COOLED RAIL FAILURE RATES TO DECEMBER 31, 1957 BY MILLS - ALL TYPES EXCEPT ENGINE BURN FAILURES - SERVICE AND DETECTED.

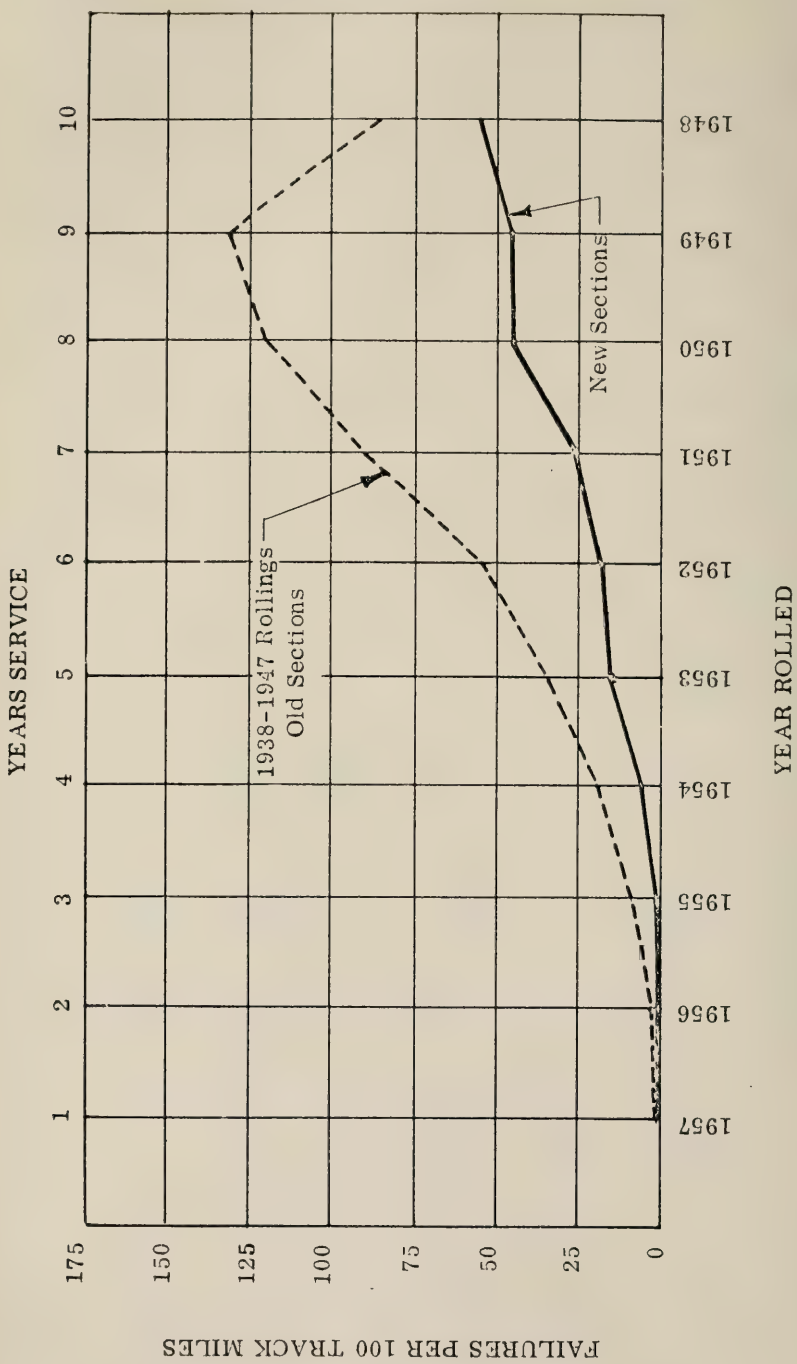

Fig. 4 - Control Cooled Rail Failures to December 31, 1958 Per 100 Track Miles - All Types Excluding Engine Burn Fractures - Service and Detected.

Report on Assignment 5

Economic Value of Various Sizes of Rail

J. C. Jacobs (chairman, subcommittee), John Ayer, Jr., S. H. Barlow, H. B. Berkshire, Blair Blowers, T. F. Burris, C. A. Colpitts, C. O. Conatser, L. S. Crane, W. J. Cruse, G. H. Echols, D. T. Faries, O. E. Fort, C. E. R. Haight, W. H, Hobbs, T. B. Hutcheson, H. S. Loeffler, Embert Osland, R. B. Rhode, J. G. Roney, J. F. Shaffer, W. D. Simpson, H. F. Smith, A. P. Talbot, J. S. Wearn, W. L. Young,

Your committee submits the following report as information. It is a continuation of Study "A", reflecting changes in the test mileage and computed to show averages after 15 years. The labor and material averages are computed to compensate for the decrease in test track mileage.

Study A

Result of Study of Illinois Central Railroad Northward Track, Mattoon, to Savoy, Ill. Test Sections of 112-Lb and 131-Lb Rail

112-Lb Rail

MP 152.24–172.00 laid in 1942 and 1943
Original test included:

19.76 track miles
18 turnouts
1 railroad crossing
22 public road crossings
2 private grade crossings
24″ joint bars

Changes in rail mileage:

1950—MP 152.09–152.24 laid in 115-lb, 0.15 miles added to test.
1952—MP 155.87–160.52 relaid in 132-lb, 4.65 miles dropped from test.
1953—MP 160.52–163.55 relaid in 132-lb, 3.03 miles dropped from test.
1954—MP 152.09–155.87 relaid in 132-lb, 3.78 miles dropped from test.
1956—MP 170.79–172.00 relaid in 132-lb, 1.21 miles dropped from test.
1957—MP 170.79–163.55 relaid in 132-lb, 7.24 miles dropped from test (Completing removal of 112-lb rail).

131-Lb Rail

MP 132.00–152.24 laid in 1944
Original test included:

20.24 track miles
21 turnouts
3 railroad crossings
22 public road crossings
6 private grade crossings
36″ joint bars

Changes in rail mileage:

1950—MP 152.09–152.24 laid in 115-lb, 0.15 miles dropped from test.

Average Annual Traffic Density—28,000,000 gross tons

Comparison of the Two Sections, Cost of Investment—1944 Prices

Item	*Investment Charges per Mile* *112 Lb*	*131 Lb*
Gross cost—rail and other track material	$12,643	$14,413
Less estimated salvage ....Cr.	4,284	Cr. 5,011

Item	Investment Charges per Mile 112 Lb	131 Lb
Net cost—rail and other track material	$ 8,359	$ 9,402
Labor cost to lay	1,338	1,473
Total cost	$ 9,697	$10,875
Estimated life—based on 1958 condition	15 years	20 years
Annual Cost—Rail and other track material	$ 557	$ 470
Labor to lay	89	74
Interest at 6 percent*	839	953
Total annual investment cost	$ 1,485	$ 1,497

* On gross outlay for material and labor.

Maintenance Labor and Material Per Mile

112 Lb					131 Lb				
Year	Miles Maintained	Man-Hours	Cross Ties	Cu Yd Ballast	Year	Miles Maintained	Man-Hours	Cross Ties	Cu Yd Ballast
1943	19.76	2,480	716	628					
1944	19.76	413	5	17	1944	20.24	2,606	1,065	647
1945	19.76	701	236	251	1945	20.24	131	0	30
1946	19.76	1,166	416	579	1946	20.24	370	5	114
1947	19.76	645	208	273	1947	20.24	748	172	301
1948	19.76	1,005	186	294	1948	20.24	245	38	185
1949	19.76	1,574	541	423	1949	20.24	670	10	116
1950	19.91	694	174	159	1950	20.09	1,642	402	323
1951	19.91	667	48	193	1951	20.09	614	59	52
1952	15.26	748	30	140	1952	20.09	1,144	62	304
1953	12.23	1,110	91	292	1953	20.09	1,089	139	120
1954	8.45	543	44	83	1954	20.09	392	0	21
1955	8.45	239	32	159	1955	20.09	631	91	64
1956	7.24	401	8	0	1956	20.09	535	10	52
1957	7.24	274	40	0	1957	20.09	394	0	0
					1958	20.09	242	78	214
Total 15	Years	12,660	2,775	3,491	Total 15	Years	11,453	2,131	2,543

Average of 15 Years

	112 Lb		131 Lb		Savings by Use of 131 Lb	
	Charge	Percent	Charge	Percent	Charge	Percent
Man-hours	844		764		80	
Cost at $1.25*	$1,055	55	$ 955	60	$ 100	33
Cross ties	185		142		43	
Cost at $3.32*	$ 614	33	$ 471	30	$ 143	46
Ballast (stone and slag) Cu Yd	233		170		63	
Cost at $1.00*	$ 233	12	$ 170	10	$ 63	21
Total maintenance	$1,902		$1,596		$ 306	
Percent		100		100		100
Investment Charges	$1,485		$1,497		$ 12 Cr.	
Total cost	$3,387		$3,093		$ 294	
Percent						8.7

*Average prices 1943–1958.

SUMMARY

At the beginning of this study the estimated service life in the first location was 15 years for the 112-lb and 25 years for the 131-lb rail. It now appears that 20 years for the 131-lb will be more nearly correct. The remainder of the 112-lb rail was removed in September 1957 after 15 years of service.

The study will be continued with respect to the 131-lb rail so long as it remains in its present location.

The greater savings realized through the use of 131-lb rail has been in cross ties, possibly due to the use of longer and heavier joint bars, larger tie plates and greater rail rigidity.

Similar maintenance standards have been practiced on both test sections.

Report on Assignment 8

Causes of Shelly Spots and Head Checks in Rail: Methods for Their Prevention

W. H. Hobbs (chairman, subcommittee), W. D. Almy, John Ayer, Jr., F. W. Biltz, B. Bristow, T. F. Burris, C. J. Code, C. O. Conatser, L. S. Crane, W. J. Cruse, D. T. Faries, C. J. Henry, C. C. Herrick, S. R. Hursh, T. B. Hutcheson, W. M. Jaekle, K. K. Kessler, R. F. Lawson, Lee Mayfield, Ray McBrian, B. R. Meyers, J. G. Roney, W. D. Simpson, J. S. Wearn, Edward Wise, Jr.

This is a progress report, presented as information.

During the past year this investigation has been limited to that conducted by (a) the AAR Engineering Division research staff, and (b) the University of Illinois. The AAR provides funds to support the work performed by its Engineering Division research staff, and the AAR and AISI jointly provide funds to support the work conducted by the University of Illinois.

That portion of the work conducted by the AAR Engineering Division research staff is under the general direction of G. M. Magee, director of engineering research, and is covered by report prepared by Kurt Kannowski, metallurgical engineer, which is included in this report as Appendix 8–a. It covers inspections of service tests of heat-treated and alloy-steel rail installations at five locations. There are three tests of heat-treated rail and two of high-silicon rail.

The heat-treated rail in tests on the Norfolk & Western Railway continues to show decided increased life over standard rail. Heat-treated rail used on the low side of curves has an increased life of 5 to 8 times and on the high side of curves, 3 to 4 times.

High-silicon rails have shown greater resistance to the detrimental effects of heavy wheel loads in the low side of curves than standard rails.

That portion of work conducted by the University of Illinois is covered by report prepared by Professor R. E. Cramer, which is included in this report as Appendix 8–b. It covers results of (1) rolling-load tests to produce shelling in 133-lb high-silicon rail, (2) rolling-load tests to produce shelling in standard carbon-steel rails, (3) rolling-load tests to produce shelling in 50-kg rails induction hardened in Japan, (4) rolling-load tests to produce shelling in flame-hardened rails, (5) rolling-load tests of high-manganese high-silicon rails, and (6) rolling-load tests to produce detailed fractures from shelling. Brief descriptions of the Union Pacific and Japanese hardening methods are also included in this report.

Appendix 8–a

Report on Service Tests of Heat-Treated and Alloy-Steel Rail

Chesapeake & Ohio Railway Service Test of 132-Lb RE Heat-Treated Rail

This test installation is described extensively in the AREA Proceedings, Vol. 57, page 833.

The 12 heat-treated (oil quenched) and the 12 non-heat-treated, end-hardened 132 RE rails near Martha, W. Va., were inspected May 5, 1959. These rails were laid in the high and low sides of the northbound (loaded) track in a 3-deg 6-min curve on May 2, 1949. They have carried approximately 267,000,000 gross tons of traffic to date.

Heat-treated rail 87581–D11 is the only test rail in which gage corner service developments were not apparent. Head checks and accompanying black areas, along with a series of black spots, appeared in the other five heat-treated rails on the high side of the curve.

Non-heat-treated rail 87581–C37 was turned end for end on April 3, 1958, the field side thus becoming the gage side of the rail. The change was made on account of the shelling which had developed in the gage corner since the rail has been in service. This is the only change in the rails in this test installation.

Two more of the non-heat-treated rails had developed shells in the gage corner of the head, and flaking and black spots were noted in the other three non-heat-treated rails.

Both the heat-treated and non-heat-treated rails in the low side of the curve appear in excellent condition, with more plastic flow noted in the non-heat-treated rails. Comparatively speaking, progression of the service developments in these test rails has been slow.

Even though not pertinent to this report, it may be of interest to note the following data on rail wear. Wear measurements were made by C&O personnel just prior to this inspection. Considerably more wear was noted in the non-heat-treated than in the heat-treated rails.

	Heat-Treated	*Non-Heat-Treated*
Head Wear:		
High rail	0.039 in	0.073 in
Low rail	0.051 in	0.090 in
Gage Wear:		
High rail	0.048 in	0.082 in

Norfolk & Western Railway Service Test of 132-Lb RE Heat-Treated Rail at Kermit

A final report on the service test of the 132-lb RE heat-treated rail at Kermit, W. Va., was given in 1957, and may be found in the Proceedings, Vol. 58, pages 1031–1032.

An inspection was made of the heat-treated (oil quenched) and the non-heat-treated end-hardened rail test in the 6-deg curve in the westbound (loaded) track just west of Kermit on May 6, 1959. The rails in this test, which originally consisted of 23 heat-treated and 24 non-heat-treated rails laid in both the high and low sides of the curve, were installed May 3, 1949, 10 years ago.

Only 8 of the original 12 heat-treated rails remain in the high side and 10 of the original 11 in the low side of the curve.

However, these remaining heat-treated rails are, generally speaking, in better condition than the adjacent non-heat-treated replacement rails in both the high and low sides of the curve. In the high side this is the third set of non-heat-treated rails while in the low side it is the fifth set.

The 18 heat-treated rails have carried an estimated 406,800,000 gross tons of traffic to May 1, 1959.

The almost complete change to diesel power from the heavy steam locomotives, principally within the last year, has had quite an effect on the appearance of the test rails in the high side of this curve. Higher train speeds through the curve are possible with diesel power, thus the wheel bearing pattern on the rails is altered. The tractive effort is exerted through the smaller diameter diesel wheels which also track differently on the heads of the rails. The result is that many of the head surface areas which appeared black at the time of previous inspections, indicating the presence of a subsurface fracture, had become polished and had lost definition. Obviously the subsurface metal rupture (shell) was still present, and it will be interesting to observe the results of reworking the surface metal at these specific locations.

The heat-treated rail, 87581–D13, in the high side of the curve still showed no signs of service developments in the gage corner. It was marked by two driver burns. Flaking, black spots, and shelling in various combinations were noted in the remaining high-side heat-treated rails. Comparison of the apparent condition with photographs made earlier indicated only a slight progression of the gage corner service developments.

Except for a few engine-wheel burns and a tendency toward crushing of the head metal near the receiving ends of some of the rails, the condition of the heat-treated rails in the low side of the curve was good. The resistance to general crushing has been outstanding.

Norfolk & Western Service Test of 132-LB RE Heat-Treated Rail at Maher and Looney's Curve

These installations on the 6-deg curve near Maher, W. Va., at M. P. 481 + 210 ft and on the 4-deg, 7-deg and 12-deg Looney's Curve at M. P. 455 + 582 ft are described extensively in the AREA Proceedings, Vol. 57, pages 834–835.

Sixty-six 132-lb RE heat-treated rails were installed in both the high and low sides of the 6-deg curve at Maher on August 2 and 9, 1954. They have carried approximately 166,800,000 gross tons of traffic.

At the time of the May 6, 1959 inspection there was little protection against wear for the rails in this curve, since the curve oilers appeared to be ineffective.

A progression of the gage corner service developments in the past year was noted. A comparison of the conditions found in the high-side heat-treated rails at the time of the 1957 and 1958 inspections, as well as the conditions noted during this inspection, follows:

Service Development	*May 1957*	*May 1958*	*May 1959*
Head checks	15 rails	7 rails	3 rails
Light flaking	20 rails	13 rails	24 rails
Medium flaking	25 rails	27 rails	15 rails
Heavy flaking	3 rails	10 rails	11 rails
Black spots	2 rails	6 rails	4 rails
Small shells	None	1 rail	6 rails
Removed from service	1 rail	2 rails	3 rails

One heat-treated rail, 81033–F18, was removed from service prior to the 1957 inspection due to an indication recorded during a Sperry Car inspection of the rails. Another heat-treated rail, 87062–D35, was removed from service in 1958, and in April 1959 heat-treated rail 81033–F12 was removed. All three rails developed detailed fractures from shelling in the high side of the curve.

In the low side of the curve two rails, 87062–C16 and D2, showed mild indications of crushing under the heavy wheel loads, while all the other rails appeared to be standing up well.

It is of interest to note that the rail in this installation was transposed on September 21, 1959, after 168,900,000 gross tons had passed over it. This new phase in the investigation will help to determine whether this operation has sufficiently increased the life of the rail to make it economical.

Fifty-five heat-treated (oil quenched) rails were laid in the high side and 54 in the low side of the compound Looney's curve on August 2 and 9, 1954. An inspection was made on May 7, 1959.

These 132-lb RE test rails have carried an approximate 94,500,000 gross tons of traffic to date. The curve oilers which have kept the rails well lubricated since installation were not operating very effectively, and the gage corners of the rails were relatively free of grease.

Following is a rough tabulation of the apparent head condition of the highside rails as noted in May 1958 and 1959:

Service Development	*May 1958*	*May 1959*
Head checks	3	0
Light flaking	17	15
Medium flaking	1	1
Heavy flaking	0	0
Black spots	3	3
Shelling	7	13
Clear	24	23

Half (27) of the heat-treated rails in the low side of the curve apparently had resisted the crushing action of the heavy wheel loads, while the other 27 showed signs of crushing in the form of breaks in the plastically deforming surface head metal.

There has been a slow progression of the service developments in the rail in both the high and low sides of this curve in the last year. But after 57 months, the rails looked relatively good in a location where non-heat-treated rails had previously lasted only 15 to 18 months in the high side and 6 to 9 months in the low side of the curve.

Pennsylvania Railroad Service Test of 140-Lb RE High–Silicon Rail

This test installation of high-silicon 140-lb RE rail is located in the Pennsylvania Railroad Altoona District No. 4 track east of Mifflin, Pa., between M. P. 152 and M. P. 153 + 2530. The test rails are installed in the 5-deg Mifflin Reverse Curve, in the 3-deg 15-min Stone House Curve, and in the 2-deg Casners Curve in alternating groups of three high-silicon and three standard high-carbon rails on both the high and low sides of the curves. The high-silicon rails are from the heat number 01H312 produced by the Edgar Thompson Plant of the United States Steel Corporation. The chemistry of this rail was as follows:

Carbon	0.83 percent
Manganese	0.75 percent
Phosphorus	0.03 percent
Silicon	0.44 percent
Sulfur	0.34 percent

The comparison rail is standard blue-end rail used in curves. The test was installed in June 1956, and at the date of the inspection on May 19, 1959, 101,564,000 gross tons of traffic had passed over it. It was noted during this inspection that very little

difference existed between the high-silicon and the standard high-carbon rail in regard to gage corner developments in the nature of shelling. The amount of light and medium flaking had increased somewhat over last year but had not developed to any serious extent. The curve oiler was noted to be in operation.

Pennsylvania Railroad Service Test of 155-Lb PS High–Silicon Rail

An inspection of this test installation of 155-lb PS high-silicon rails produced at Steelton in September 1953 was made on May 19, 1959. An extensive description can be found in the Proceedings, Vol. 53, page 1029.

These rails were laid October 5–8, 1953, in the No. 1 eastbound track in the 2-deg 37-min Bixler Curve, M. P. 164, east of Lewiston, Pa. Alternate groups of 5 high-silicon rails and 5 rails of standard analysis (blue ends) were installed in the high and low sides of the curve. All rails were end hardened at Steelton.

The analysis for the heat 86N594 follows:

C	*Mn*	*P*	*S*	*Si*
0.79	0.72	0.01	0.034	0.59

The previous 152-lb PS rails in this curve had shown light to medium flaking with some shelling spots in the high-side rails after 12 years of service. One rail contained eight light shells. In the low side of the curve the previous 152-lb PS rails showed considerable crushing.

At the time of the May 1958 inspection light to medium flaking was common to both the high-silicon and the standard analysis rails in the portion of the curve at full elevation. This was a change from the May 1957 inspection, at which time less flaking was apparent in the high-silicon rails than in the rails of standard analysis. No shelling or black spots had been noted through the May 1958 inspection.

Due to a rail relay program the test rails on the curve had been transposed prior to the inspection this year. Even though this defeated the observation of the comparative performance of high-silicon and standard rail, interesting data of the effect of transposing were obtained. A total of 184,770,000 gross tons of traffic had been carried by the test rails to January 1, 1959.

One feature worthy of note was observed during the inspection of the rails as transposed. At the time of the May 1958 inspection, three of the standard-analysis rails in the low side of the curve were noted to have areas of broken or chipped head surface due to plastic deformation under the crushing wheel loads. During the recent inspection 7 standard analysis rails or 28 percent of the 25 which had been transposed from the low to the high side were noted to contain this condition. Undoubtedly the condition occurred in the four additional rails while they were still in the low side of the track. This surface chipping or indication of crushing was not noted in any of the high-silicon rails. This fact would indicate that the high-silicon rails have shown greater resistance to the detrimental effects of heavy wheel loads in the low side of the curve than the standard-analysis rails.

A

Appendix 8–b

Shelly Rail Studies at the University of Illinois

By R. E. Cramer
Research Associate Professor, University of Illinois

Organization and Acknowledgment

The shelly rail investigation at this laboratory is financed equally by the American Railway Engineering Association and the American Iron and Steel Institute. John Finley, student test assistant, worked on a part-time basis, and Marion Moore, mechanic, repaired and operated the rolling-load machines.

Rolling-Load Tests to Produce Shelling in 133-Lb High–Silicon Rail

Tests had been delayed on this specimen of high-silicon rail containing 0.65 percent silicon. Two rolling-load tests have been completed which ran 1,944,400 cycles and 1,480,200 cycles. The mechanical properties and rolling-load tests are listed in Table 1 of this report. A picture of the shelling failure produced in specimen 1192A is shown in Fig. 1. This failure is typical of most shelling produced in laboratory rolling-load tests.

Rolling-Load Tests to Produce Shelling in Standard Carbon-Steel Rails

As is customary, a standard carbon-steel rail is occasionally tested for comparison with the alloy rails furnished for tests. When the three specimens of gage-corner-induction-hardened rails were supplied by the Teleweld Company (see Proceeding, Vol. 60, page 941) it also supplied a 6-ft length of the same steel not flame hardened. This rail was identified as 132-lb section from the Gary Mill, Heat No. 758015–C–21, rolled in November 1956. Two rolling-load tests were made on this rail as specimen No. 1196, which gave unusual results of 4,347,000 cycles and 4,371,000 cycles. The mechanical tests of the rail, as shown in Table 1, were quite typical of standard carbon-steel rails. In the rolling-load tests the specimens developed high plastic flow before the shelling cracks reached the side of the rail head, which is the end of the tests (see Fig. 1).

To study the steel in this rail for an explanation of these long rolling-load tests, specimens were cut for metallographic examination for inclusions. At this laboratory rail steel is judged by the number of inclusions found that are over ½ in long when examined at 100 × magnification. It was necessary to grind and repolish the specimen from this rail several times before even one non-metallic inclusion was found which was over ½-in. in length. It appears that this steel was unusually free of large inclusions, which could be one explanation of why it flowed so much before developing a shelling crack.

Rolling-Load Tests to Produce Shelling in 50-kg Rails Induction Hardened in Japan

Research representatives of Yawata Iron and Steel Company, Ltd., Tokyo, Japan, visited the University research laboratory in July 1958. They showed reports on induction-hardened rails and expressed a desire to have rolling-load tests made on their product. They furnished two 6-ft lengths of their 50-kg section, induction hardened to about 320 Brinell hardness. Their rail was given specimen No. 1197. Their hardened zone, as shown in Fig. 2, is deep enough to obtain specimens for all the mechanical tests listed in Table 1. These mechanical tests are very high; however, the rolling-load tests ran only 517,400 cycles and 718,300 cycles until a shelling crack developed on the side of

TABLE 1—MECHANICAL TESTS AND ROLLING-LOAD TESTS, OCTOBER 1, 1959–SEPTEMBER 30, 1959

Spec. No..	Chemical Analysis			Size and Kind of Rail	Avg. Brin. Hard.	Yield Strength 2% PSI	Tensile Strength PSI	Elong. in 2 in %	Red. of Area %	Charpy Values Ft-Lb		Endurance Limit PSI	Cycles for Failure 50,000-lb Wheel Load
	C	Mn	Si							No Notch	Key Hole		
1192A B	0.75	0.94	0.65	133-lb high-silicon, Colorado for Phelps Dodge	300	85,800	151,700	7.3	14.2	100	3.6	67,500	1,944,400 1,480,200
1196A B	0.74	0.86	0.17	132-lb standard rail, companion to Teleweld s	277	73,000	134,200	7.7	17.3	110	1.5	61,000	4,347,000 4,371,000
1197A B	0.65	0.78	0.13	50-kg rail from Japan, induction-hardened head	320	116,000	159,000	12.0	42.5	320	8.7	94,000	512,400 718,300
DUP2	0.74	0.82	0.15	Double flame hardened by UP immersion method	353								4,785,000
UP1A B	0.74	0.82	0.15	Single-flame hardened by UP immersion method	351								3,382,000 3,403,800
UP3A B	0.75	0.82	0.19	Single flame-hardened by Am. Brake Shoe Co.	339								1,490,000 6,433,800
1198A B	0.61	1.08	0.88	136-lb Hi. Si, Hi. Mn, Colorado for experiments	272	78,100	137,600	9.3	22.9	210	6.8	68,500	2,415,000 1,850,000
1199A B	0.61	1.08	0.88	136-lb Hi. Si, Hi. Mn, Colorado for experiments	270	78,100	137,700	8.5	20.5	188	4.5	61,000	1,792,400 3,260,500

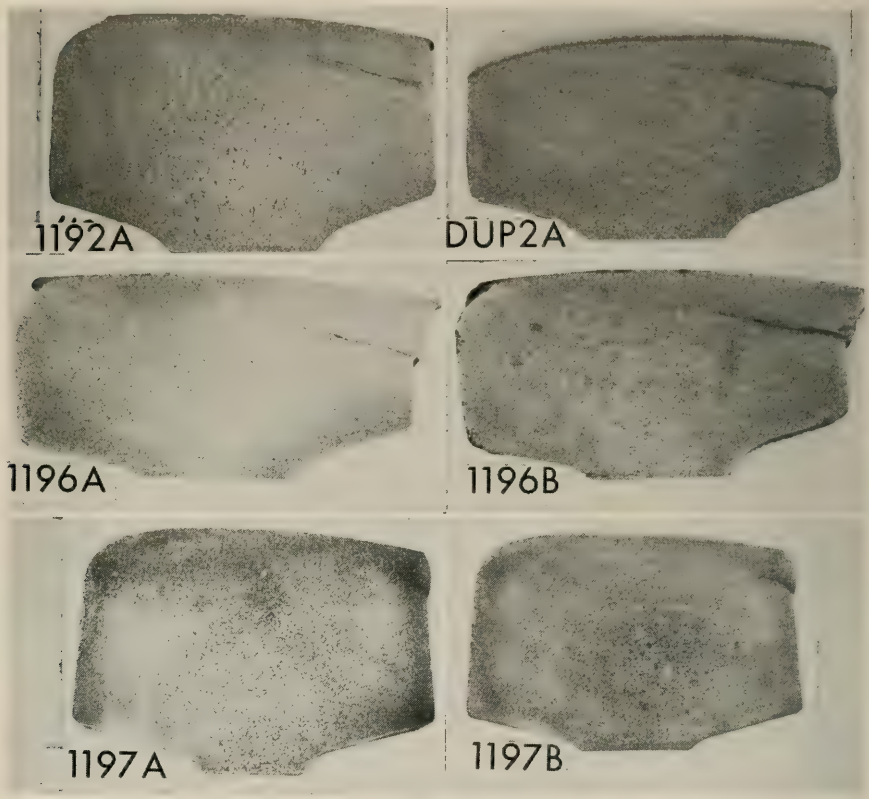

Fig. 1—Shelly Failure Produced in Rolling-Load Tests.

Specimen Number	*Size and Kind of Rail*	*Average Brinell Hardness*	*Cycles of 50,000-Lb Wheel-Load*
1192A	133-lb high-silicon rail	300	1,944,400
DUP2A	Double flame-hardened std. rail	370	4,785,200
1196A	132-lb standard carbon rail	277	4,347,000
1196B	132-lb standard carbon rail	277	4,371,600
1197A	50-kg ind.-hardened Japanese rail	320	512,400
1197B	50-kg ind.-hardened Japanese rail	320	718,300

the rail head. Cross sections of the two specimens tested are shown in Fig. 1. It will be seen that the shelling cracks are not deep into the rail head. It is thought that the shape of the rail head plays a part in where the shelling cracks develop, and those which develop near the surface do so at relatively fewer cycles than when the shelling crack develops deeper inside the rail head.

Brief Description of Japanese Induction-Hardening Method

In this method 3,000-cycle high-frequency current is used through a coil which generates secondary current in the rail head which heats the rail steel. Optical pyrometers are used to measure the temperature. The temperature for hardening the rails is approxi-

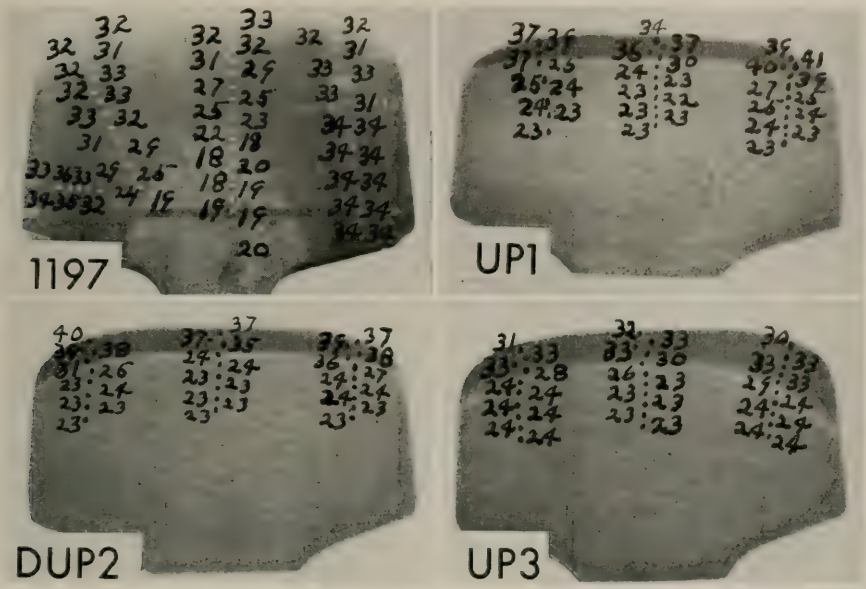

Fig. 2—Rockwell C hardness of hardened rails. Specimens etched with ammonium persulfate.

Specimen Number	*Size and Kind of Rail*
1197	50-kg induction-hardened Japanese rail
UP1	133-lb single flame hardened by UP immersion method
UP2	133-lb double flame hardened by UP immersion method
UP3	133-lb single flame hardened by American Brake Shoe Company

mately 1525 F, and the highest temperature used for tempering is approximately 1110 F. Hardening is done by a cold-water jet through a jacket, hitting the head surface of the rails immediately after its passage through the stationary heating coil. The hardened part of the rail moves into the tempering coil and is tempered here to the desired hardness. The rail is again cooled with water after tempering.

Rolling-Load Tests to Produce Shelling in Flame-Hardened Rails

J. A. Bunjer, chief engineer, Union Pacific Railroad, supplied three 133-lb rail specimens with the surfaces flame hardened by two processes. One process was carried out in the UP shops and is as follows: a full-length, 39-ft rail is placed in a tank with a short piece of rail bolted to each end by joint bars. The rail is supported, head up, at the center and cambered down by means of a 50-ton hydraulic jack a distance of 13¾ in from each end.

The tank is filled with water up to ¼ to ⅜ in from the top of the rail at each end, and a multi-jet oxyacetylene flame-hardening head moves over the rail at a speed of 4½ in per min. As this head moves up the rail, water is let into the tank so that it is always ¼ in down below the head at the point of the flame hardening. After the head has moved over half the length of the rail with the water rising beind it, it then starts down the other half of the rail, and the water is receded at the same rate; that is,

there is always water within ¼ in of the top of the rail at the point it is being flame hardened.

Another way to perform this hardening would be to start a flame hardening head at each end of the rail as the tank is filled with water. When the heads approached the center of the rail one head would have to be removed and there would be some overlapping of the area flame hardened, thus producing a short area that was double flame hardened. In order to test the effect of this double flame hardening, one specimen, identified as DUP2, was produced for rolling-load tests. The results of the hardness tests on this specimen are shown in Fig. 2, where it may be compared to specimen UP1 which was flame hardened by the same process only once. There is very little difference either in the Rockwell C hardness or in the depth of the hardened zone as indicated by the etching of the specimens. The Rockwell C readings may be multiplied by 10 to give approximate comparison to Brinell hardness. The rolling-load test of this specimen gave 4,785,000 cycles compared to 3,382,000 and 3,403,800 for two specimens of UP1, which was given only one flame hardening. All of these tests are far superior to any flame-hardened rails previously tested at this laboratory. The one rolling-load test of the double flame-hardened rail could indicate that the double flame hardening was beneficial, but no conclusions should be drawn from just one test of a new process. Other specimens have been prepared to make further tests of this double heat treatment.

The third specimen, No. UP3, supplied by the Union Pacific was flame hardened by the American Brake Shoe Company at its Pueblo plant. A brief description of its process was requested and is as follows:

"The rail is set on the bed or framework of the machine, and a flame and quenching head is moved along a track above the rail at a speed determined by the area to be hardened. The flame head, air quench head and water cooling head are connected together so as to move along the track with a predetermined distance between them at a predetermined speed. The flame heats the full section of rail and brings that part which is to be hardened above the critical or transformation temperature. The air quenching head reduces the temperature below the lower transformation point, producing the surface hardness where desired, and the water spray cools the rail. The heating of the full section of the rail prevents undue warpage which would occur if only that part which was to be hardened was heated."

The hardness tests of the specimen flame hardened by the American Brake Shoe Company are shown in Fig. 2, specimen UP3. The hardest readings are Rockwell C 33 or about 330 Brinell compared to 39 Rockwell C or about 390 Brinell for the immersion-hardened specimens, Nos. UP1 and UP2.

It appears from the results of these few tests of flame-hardened rails that methods may have been found which are quite satisfactory for flame-hardening rails. However, more tests must be made before this fact is fully established.

Rolling-Load Tests of High-Manganese High-Silicon Rails

Two rails, Nos. 1198 and 1199, were supplied with 0.61 percent carbon, 1.08 percent manganese and 0.88 percent silicon. The average Brinell hardnesses of these rails were 272 and 270. Their mechanical tests as given in Table 1 are quite similar to standard carbon-steel rails. However, the rolling-load tests, which varied from 1,792,400 cycles to 2,415,000 cycles, are more like the rolling-load tests of high-silicon steel rails. Pictures of the failures produced in three of these specimens are shown in Fig. 3 as Nos. 1198A and B and No. 1199A. It is expected that more specimens will be supplied with higher manganese content for future tests.

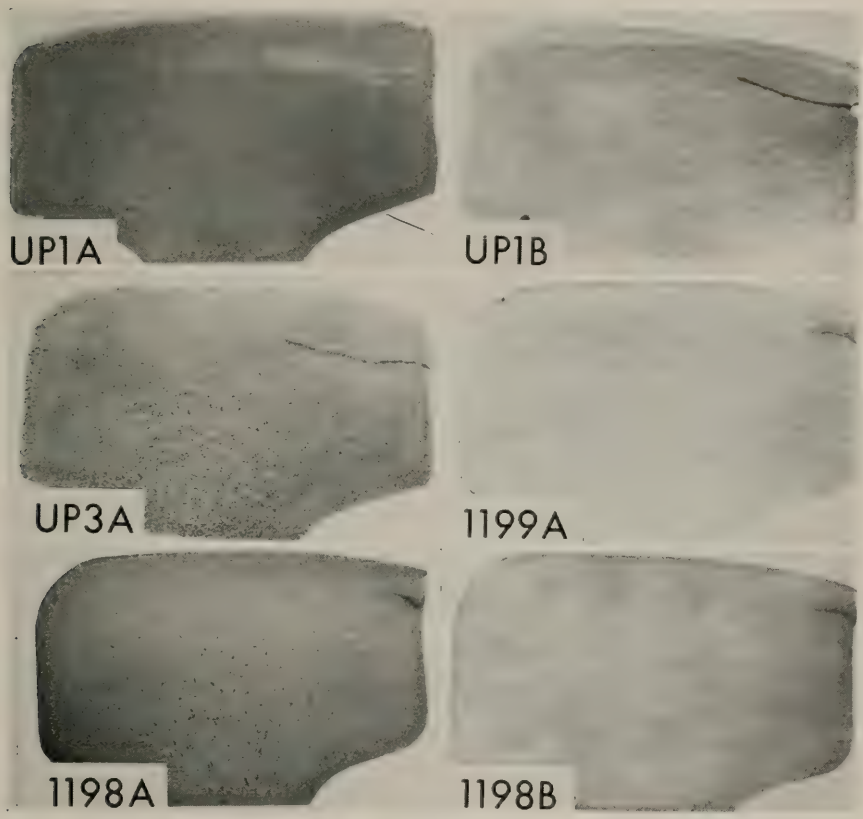

Fig. 3—Shelly Failures Produced in Rolling-Load Tests.

Specimen Number	*Size and Kind of Rail*	*Average Brinell Hardness*	*Cycles of 50,000-Lb Wheel-Load*
UP1A	133-lb single flame hardened, UPRR	351	3,382,000
UP1B	133-lb single flame hardened, UPRR	351	3,403,800
UP3A	133-lb single flame hardened, Am. Brake Shoe	339	1,490,000
1199A	136-lb high manganese high silicon	270	1,792,000
1198A	136-lb high manganese high silicon	272	2,415,000
1198B	136-lb high manganese high silicon	272	1,850,000

Rolling-Load Tests to Produce Detailed Fractures from Shelling

In last year's report rolling-load tests to produce shelling were reported on three specimens of extremely high silicon with the analysis: carbon 0.75 percent, manganese 0.97 percent, and silicon 1.63 percent. These rails averaged 1,121,700 cycles for failure. The rolling-load test to produce detail fractures from shelling uses a specimen with a slot cut in the rail web so the end of the rail head can bend down. In general, it takes more cycles to develop a detail fracture than ordinary shelling. That proved to be the case with two tests of the extremely high-silicon steel. The first test developed a 12

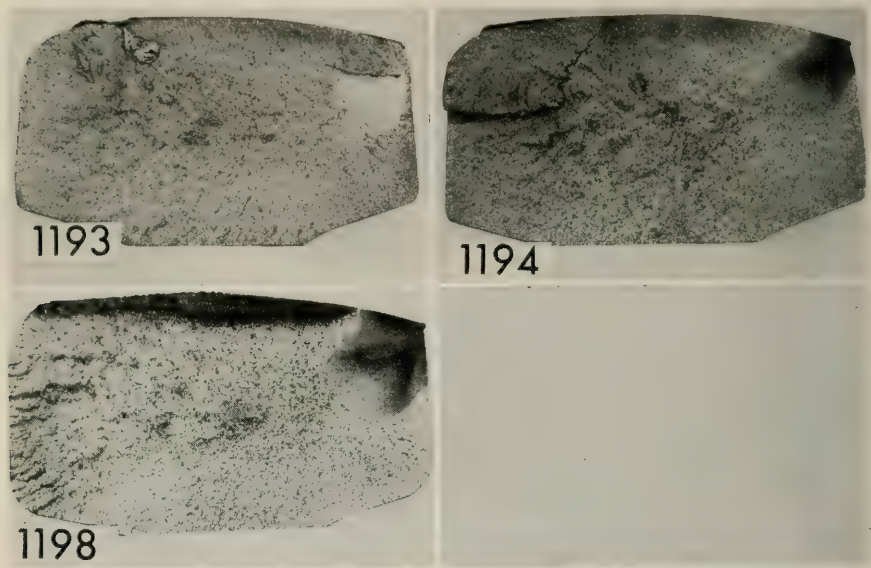

Fig. 4—Detail Fractures from Shelling Produced in the Laboratory.

Specimen Number	*Kind of Rail*	*Type of Fracture*	*Average Brinell Hardness*	*Cycles of 50,000-Lb Wheel Load*
1193	133-lb extra high Si	10% detail from shelling	321	2,007,400
1194	133-lb extra high Si	10% detail from fin.	322	5,204,900
1198	136-lb high Si high Mn	20% detail from fin.	272	4,492,200

percent detail fracture at 2,007,400 cycles, and the second test failed at 5,204,900 cycles. It has not been unusual to have this much difference in rolling-load tests to produce detail fractures due to the nature of the test. Pictures of the failures produced in these two rails are shown in Fig. 4, specimens 1193 and 1194.

A third rail was rolled to produce a detailed fracture as shown by specimen No. 1198 in Fig. 4. This was a high-silicon high-manganese rail whose chemical analysis and mechanical tests are listed in Table 1. The specimen ran 4,492,200 cycles before developing the detail fracture failure.

Summary

1. Two rolling load tests were made on a high-silicon rail, No. 1192, which ran 1,944,400 and 1,480,000 cycles.

2. A standard carbon-steel rail gave unusually long tests of 4,347,000 and 4,371,000 cycles. These specimens deformed considerably before the shelling cracks were visible on the side of the rail head.

3. Two induction-hardened 50-kg rails from Japan gave rolling-load tests of 517,400 and 718,300 cycles.

4. One double-flame-hardened specimen ran 4,185,000 cycles in the rolling-load test. This is a much higher test than previous flame-hardened specimens.

5. Single flame-hardened rails ran from 1,490,000 cycles to 3,403,800 cycles, which are also very high rolling-load tests for flame-hardened rails.

6. Two rails with high manganese and high silicon were tested. The rolling load tests varied from 1,792,400 cycles to 3,260,500 cycles.

7. Three specimens were tested to develop detail fractures from shelling. They developed the failures shown in Fig. 4 at 2,007,400; 5,204,900 and 4,492,200 cycles.

Report on Assignment 9

Standardization of Rail Sections

J. A. Bunjer (chairman, subcommittee), W. D. Almy, S. H. Barlow, H. B. Berkshire, F. W. Biltz, T. F. Burris, C. J. Code, L. S. Crane, W. J. Cruse, O. E. Fort, C. E. R. Haight, C. J. Henry, C. C. Herrick, S. R. Hursh, W. M. Jaekle, K. K. Kessler, Ray McBrian, R. B. Rhode, H. F. Whitmore, R. P. Winton, Edward Wise, Jr.

This is a progress report, presented as information.

As the result of action by the Board of Direction at its meeting on November 7, 1958, on the recommendation of Committee 4, Assignment 9 was changed for 1959 from "Recent Developments Affecting Rail Sections" to "Standardization of Rail Sections."

During 1959 the committee sent a questionnaire to all chief engineering officers of AAR Member Roads inquiring specifically as to which of the 44 rail sections now being rolled by at least one United States mill they would be in favor of eliminating, and the number of miles of track laid with each of the 44 sections on their railroad. Replies were received from 88 railroads representing 247,670 miles of road, and the accompanying tabulation (see page 882) summarizes the replies received.

In January 1960 representatives of Committee 4 met with representatives of Committee 16—Simplification and Standardization, of the Purchases and Stores Division, AAR, primarily to evaluate jointly all aspects of the economic savings to the railroads that may be possible through the standardization of rail sections.

	RAIL SECTION	CHIEF ENGR. OFFICER FROM EACH RAILROAD Eliminate Yes	No	%	TOTAL MILES EACH SECTION NOW IN TRACK OF ROADS REPORTING Eliminate Yes	No	%	TOTAL MILES OF ROADS REPORTING - 247,670 Eliminate Yes	No	%
1.	65 ASCE	85	3	96.6	2,538	13	99.5	245,370	2,300	99.1
2.	70 ASCE	84	4	95.5	3,158	87	97.3	244,670	3,000	98.8
3.	75 ASCE	83	5	94.3	6,472	574	91.9	241,040	6,630	97.3
4.	80 ARA-A	85	3	96.6	1,021	5	99.5	245,310	2,360	99.0
5.	80 ASCE	79	9	89.8	9,284	586	94.1	245,500	2,170	99.1
6.	85 Can.Pac.	82	6	93.2	1,006	3,482	22.4	200,650	47,020	81.0
7.	85 ASCE	81	7	92.0	10,024	1,639	85.9	238,310	9,360	96.2
8.	90 ARA-A	51	37	58.0	2,389	19,633	10.8	144,870	102,800	58.5
9.	90 ASCE	78	10	88.6	2,815	537	84.0	236,360	11,310	95.4
10.	90 ARA-B	78	10	88.6	2,208	1,309	62.8	229,390	18,280	92.6
11.	90 N&W	85	3	96.6	4	-	100.0	247,300	370	99.9
12.	100 CStPM&O	85	3	96.6	1,613	-	100.0	239,940	7,730	96.9
13.	100 NYNH&H	85	3	96.6	168	-	100.0	239,940	7,730	96.9
14.	100 Rdg.	84	4	95.5	-	213	-	238,660	9,010	96.4
15.	100 PRR	83	5	94.3	3	313	.9	239,580	8,090	96.7
16.	100 AREA-T	85	3	96.6	-	-	-	247,300	370	99.9
17.	100 AREA	59	29	67.0	5,073	8,801	36.6	147,010	100,660	59.4
18.	100 ARA-B	75	13	85.2	2,546	1,813	58.4	224,370	23,300	90.6
19.	100 ARA-A	69	19	78.4	1,754	9,287	15.9	199,900	47,770	80.7
20.	100 ASCE	81	7	92.0	376	1	99.7	238,070	9,600	96.1
21.	105 DL&W	83	5	94.3	-	288	-	238,840	8,830	96.4
22.	105 NYC	83	5	94.3	4,585	4	99.9	239,290	8,380	96.6
23.	106 CF&I	73	15	83.0	-	30	-	177,260	70,410	71.6
24.	107 NYNH&H	84	4	95.5	-	611	-	238,180	9,490	96.2
25.	110 AREA	80	8	90.9	3,815	717	84.2	237,010	10,660	95.7
26.	112 AREA	70	18	79.5	19,369	5,591	77.6	213,830	33,840	86.3
27.	112 CB&Q	84	4	95.5	-	1,814	-	231,250	16,420	93.4
28.	115 AREA	25	63	28.4	962	18,114	5.0	51,560	196,110	20.8
29.	118 DL&W-Mod.	83	5	94.3	-	25	-	238,840	8,830	96.4
30.	119 Inland	79	9	89.8	-	-	-	203,390	44,280	82.1
31.	119 CF&I	65	23	73.9	-	569	-	155,520	92,150	62.8
32.	127 NYC-Mod.	82	6	93.2	-	1,002	-	227,880	19,790	92.0
33.	127 NYC	84	4	95.5	5,806	2	99.9	239,760	7,910	96.8
34.	129 CB&Q	83	5	94.3	-	625	-	231,070	16,600	93.3
35.	130 PRR	80	8	90.9	50	4,251	1.2	227,390	20,280	91.8
36.	130 AREA	81	7	92.0	3,064	920	76.9	221,070	26,600	89.3
37.	131 AREA	75	13	85.2	12,490	5,080	71.1	220,610	27,060	89.1
38.	132 AREA	41	47	46.6	266	12,962	2.0	78,870	168,800	31.8
39.	132 So.Pac.	84	4	95.5	-	-	-	239,760	7,910	96.8
40.	133 AREA	68	20	77.3	15	3,784	.4	188,520	59,150	76.1
41.	136 LVRR-Mod.	81	7	92.0	-	850	-	233,940	13,730	94.5
42.	136 CF&I	62	26	70.5	-	987	-	146,870	100,800	59.3
43.	140 AREA	52	36	59.1	-	2,843	-	107,110	140,560	43.2
44.	155 PRR	78	10	88.6	138	947	12.7	213,450	34,220	86.2

Report on Assignment 10

Service Performance and Economics of 78-ft Rail, Specifications for 78-ft Rail

Collaborating with Committee 5

J. K. Gloster (chairman, subcommittee), W. D. Almy, S. H. Barlow, B. Bristow, R. E. Catlett, Jr., L. S. Crane, W. J. Cruse, D. T. Faries, O. E. Fort, C. J. Henry, S. R. Hursh, J. J. Jacobs, W. M. Jaekle, Ray McBrian, B. R. Meyers, R. B. Rhode, W. D. Simpson, H. F. Smith, A. P. Talbot, R. P. Winton, Edward Wise, Jr., W. L. Young.

Foreword

Field data were not obtained in 1959 for the test installations on the Pennsylvania Railroad near Hamlet, Ind. and the Chicago & North Western Railway near Calamus, Iowa. Hence this report covers only the service test on the Illinois Central Railroad in the southward main track (No. 1 of three tracks) south of Monee and Peotone, Ill.

The IC test, established in 1956 with the 132 RE section, was primarily for the purpose of developing proper anchorage for 78-ft rail, because anchorage of the Pennsylvania and North Western tests had not been considered adequate. Previous reports have been published in the Proceedings, Vol. 58, 1957, page 1048; Vol. 59, 1958, page 992; and Vol. 60, 1959, page 972.

The obtaining of field data and preparation of the report were carried out by the AAR Engineering Division research staff under the direction of G. M. Magee, director of engineering research, under the direct supervision of H. E. Durham, research engineer track, and members of his staff.

Discussion of Test Data

Because the rail in the test mile, M.P. 34.7 to M.P. 35.7, was laid at the relatively high temperature of 110 F, it was found that winter joint gaps were excessive when measured on January 3, 1958, at a temperature of 2 F.

In spite of the excellent anchorage, it was quite evident that rail, in 78-ft lengths, laid at 110 F would not maintain a satisfactory gap at extremely low temperatures. Therefore, to achieve a more desirable winter gap pattern, arrangements were made with the IC to reduce the gaps and to add additional rail at the end of the mile. With an AAR staff member present, the work was done by the IC forces on November 18 and 19, 1958, at average rail temperatures of 48 F on the east rail and 50 F on the west rai. The selection of shims, during progress of the work, followed closely the recommendations contained in Vol. 57, 1956, page 863. The average shim used on the east rail was 0.19 in and on the west rail, 0.18 in, which gaps were considered comparable to laying rail with zero gap at slightly more than 80 F rail temperature. A total of 8½ in was added to the east rail and 9¾ in to the west rail.

Following the work on the test mile, the IC reduced the gaps of the east rail of another section of 78-ft rail in track No. 1 between M.P. 42.0 and M.P. 42.5 south of Peotone. This one-half mile has previously been reported, because of a different anchorage pattern and the two rails having been laid at widely different temperatures. The east rail was laid tight at 117 F August 1956 and has since developed excessive gaps at low temperatures. The west rail laid at 75 F had good rail gap uniformity, and no change was made in the expansion.

Fig. 1 shows the gap patterns after adjustments were made in the test mile on November 18 and 19, 1958, and M.P. 42.0 to M.P. 42.5 on November 24, 1958. Attention is called to the increase in average gap of the east rail of the test mile when measured on November 19, the day after adjustment. This was caused by a low temperature of 35 F during the night of the 18th, creating some increase of the gaps which did not close appreciably at a temperature of 60 F.

The winter and summer gap patterns of the test mile obtained on February 6, 1959, and July 22, 1959, at average temperatures of —1.5 F and 114 F, respectively, are shown on Fig. 2. It will be noted that the average winter gap on the west and east rails was 0.33 in, which compares with 0.42 in and 0.43 in, respectively, at 2 F on January 3, 1958. The summer rail gap uniformity at 114 F in 1959 was not materially different from 1958.

In the one-half mile between M.P. 42.0 to M.P. 42.5, shown on Fig. 3, the winter gap on the west rail increased from 0.15 in at —4 F in 1958 to 0.22 in at 0.5 F in 1959, whereas a slight decrease from 0.35 in. in 1958 to 0.34 in. in 1959 was noted for the east rail. The east rail, which was adjusted in November 1958, shows a much more uniform pattern than previously. The summer gaps of the west rail are about the same as previously, being 0.03 in at 111 F in 1959 compared to 0.037 in at 120 F in 1958, but a decided improvement was indicated in the east rail, which was 0.01 in. in 1959 against 0.183 in. in 1958.

The results obtained from the reduction of gaps in November 1958 serve to give emphasis to previous statements that 90 F is the maximum desirable rail temperature for laying 78-ft rail where the annual range is about — 10 to + 130 F. It is realized that 78-ft rail cannot always be laid at a favorable temperature. However, a part of the rail program can be scheduled for the spring and fall.

Maintenance

Other than the work of closing the gaps, the only maintenance performance since installation was retightening the bolts in 1956 and after taking summer gap readings in July 1959. Normal bolt tension was used. The last wrenching of the bolts was to restore the slippage resistance of the joints and to close 14 open joints.

Acknowledgement

The Association acknowledges with thanks the excellent cooperation assistance of the Illinois Central in carrying out this service test.

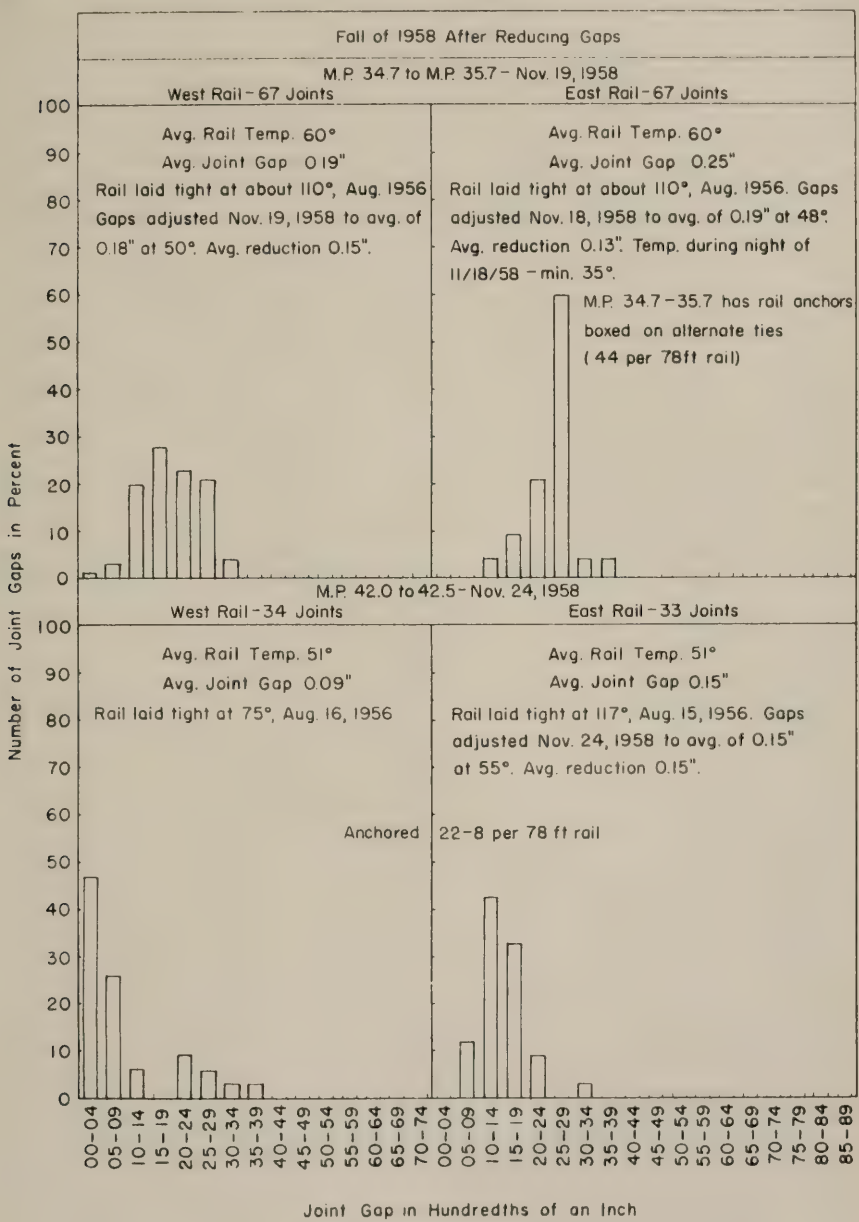

Fig. 1.—Joint Gap Measurements in 78-ft Rail, ICRR, M.P. 34.7 to M.P. 35.7 and M.P. 42.0 to 42.5 near Monee and Peotone, ILL.

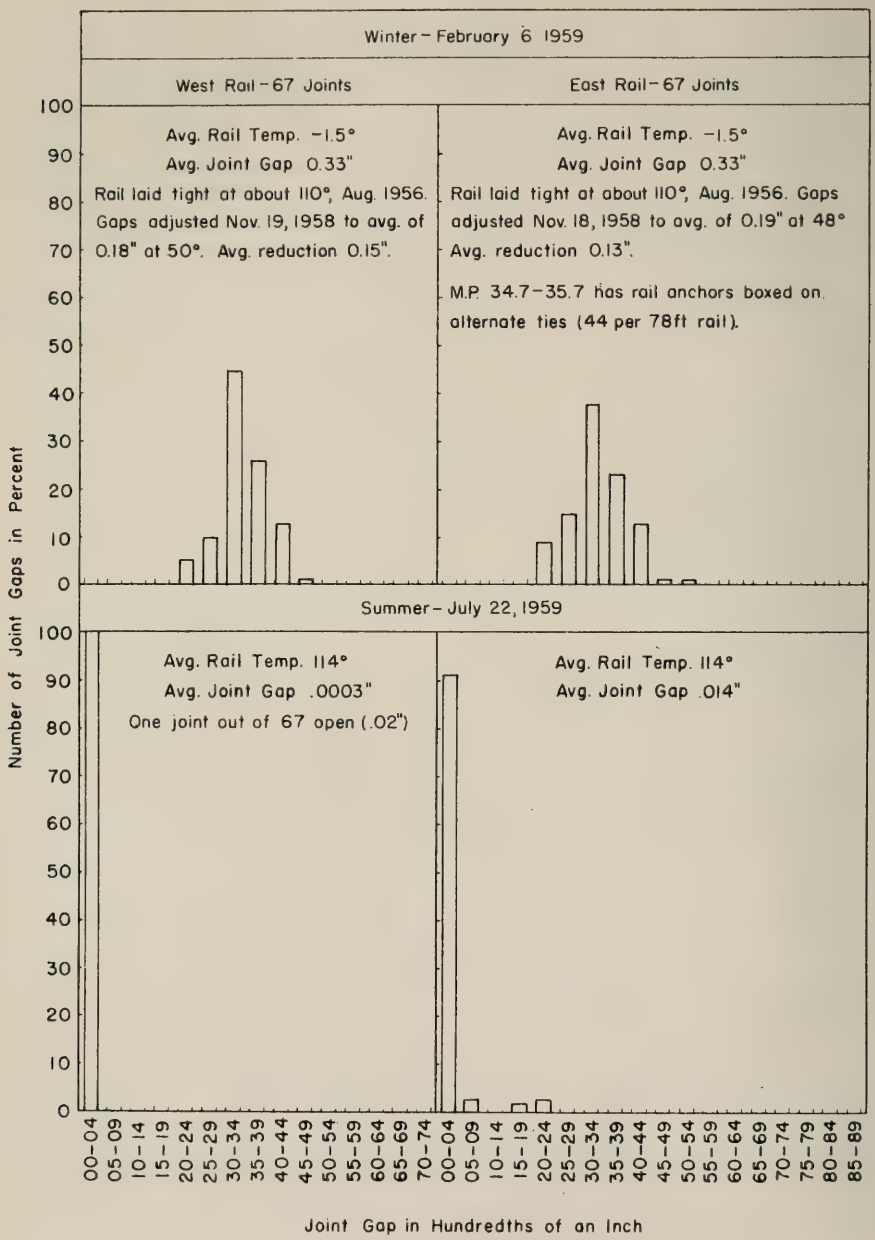

Fig. 2 — Summer and Winter Joint Gap Measurements in 78ft Rail, M.P. 34.7 - 35.7, ICRR, between Monee and Peotone, Illinois.

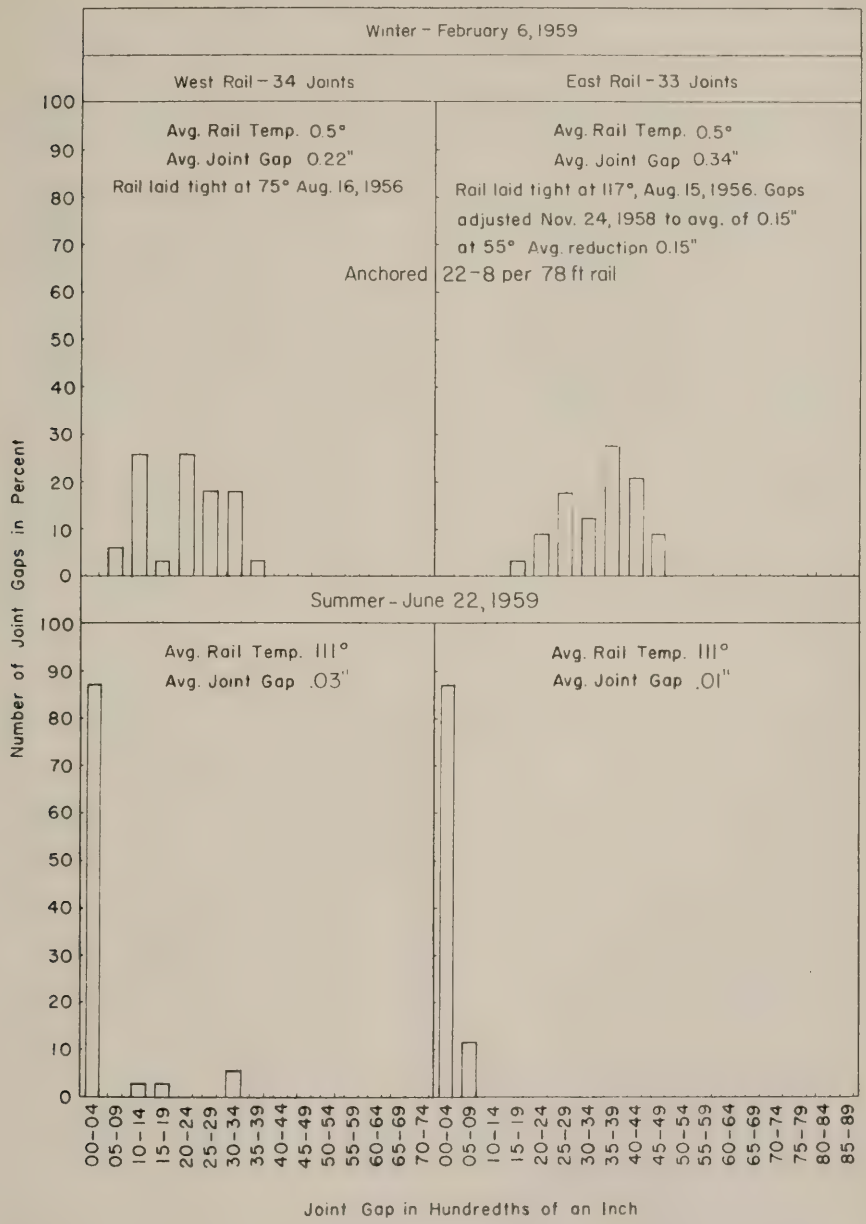

Fig. 3.—Summer and Winter Joint Gap Measurements in 78 ft Rail, M.P. 42–42.5, ICRR between Monee and Peotone, Illinois.

Report on Assignment 11

Rail Damage Resulting from Engine Burns; Prevalence; Means of Prevention; Repair by Welding

C. E. Morgan (chairman, subcommittee), F. W. Biltz, C. J. Code, C. A. Colpitts, L. S. Crane, W. J. Cruse, G. H. Echols, O. E. Fort, J. K. Gloster, C. E. R. Haight, V. E. Hall, T. B. Hutcheson, J. C. Jacobs, K. K. Kessler, Lee Mayfield, Ray McBrian, C. R. Riley, W. D. Simpson, A. P. Talbot, R. P. Winton, Edward Wise, Jr.

Your committee presents as information the accompanying tabulation showing the number of engine-wheel burns welded and the number that failed prior to December 31, 1954, and the same data for each year since then through 1958. It also presents as information a report on rolling-load tests of welded engine-wheel burns on rail supplied by the Seaboard Air Line Railroad.

WELDED ENGINE BURNS AND FAILURES REPORTED PRIOR TO DECEMBER 31, 1954
TO DECEMBER 31, 1958

Railroad	Total Engine Burns Welded Prior to December 31, 1954	Number of Engine Burns Welded During 1955	Number of FWEB's* During 1955	Number of Engine Burns Welded During 1956	Number of FWEB's* During 1956
AT&SF	920	4,626	0	12,883	0
B&O	101	54	0	603	0
C&O		15,947	9	11,368	5
C&NW	3,371	1,221	0	3,672	0
D&H	7,160	433	0	51	1
EJ&E	Did Not Report	17,122	0	9,174	0
IC	5,354	1,785	0	547	0
PRR	98,417	Did Not Report	Did Not Report	49,953	7
RF&P	11,563	6,173	0	205	2
St. L-SF	619	223	0	484	0
SAL	4,964	2,810	0	1,287	0
Southern (Sys.)	No Record	No Record	0	No Record	2
Southern (West. Div.)	123,408	14,607	0	5,648	1
SP	Did Not Report	Did Not Report	Did Not Report	Did Not Report	Did Not Report
TOTALS	255,889	65,001	15	95,875	18

WELDED ENGINE BURNS AND FAILURES REPORTED PRIOR TO DECEMBER 31, 1954
TO DECEMBER 31, 1958

Railroad	Number of Engine Burns Welded During 1957	Number of FWEB's* During 1957	Number of Engine Burns Welded During 1958	Number of FWEB's* During 1958
AT&SF	22,023	0	24,528	0
B&O	289	0	176	0
C&O	6,408	8	2,117	3
C&NW	1,996	0	1,369	0
D&H	131	1	80	3
EJ&E	8,125	1	9,980	0
IC	1,018	0	3,751	0
PRR	73,719	11	48,028	9
RF&P	0	0	0	0
St. L-SF	182	0	596	0
SAL	584	0	1,336	0
Southern (Sys.)	No Record	0	No Record	0
Southern (West. Div.)	1,928	0	Discontinued Keeping This Information	
SP	Did Not Report	Did Not Report	45	0
TOTALS	116,403	21	92,006	15

*FWEB's - Fractured or failed welded engine burns

Rolling-Load-Test Results of Welded Engine-Wheel Burns on Rail Supplied by the Seaboard Air Line Railroad

At the request of the Seaboard Air Line Railroad, as well as in the interest of investigating new approaches in repairing engine-wheel burns by welding, the following described rolling-load tests were made on welded engine-wheel burns. These welds were made by qualified railroad personnel using oxyacetylene and electric-arc methods. The oxyacetylene-welding method using the maintenance-of-way rod is the standard procedure for repairing wheel burns on the railroads. Two welds of this type were prepared as controls. Eight engine-wheel burns were then welded by means of the electric-arc method using the $\frac{3}{16}$-in McKay Frogalloy "C" electrode on four of them and the McKay Hardalloy "32" electrode on the other four. Two welds out of each of these groups of four were preheated and postheated to 1000 F while the other two had no heating.

The first six engine-wheel burns were welded on 115-lb RE rail. The burns had been in the rails five to six years. The defective metal was removed by grinding and checked with Magnaflux Spot Check. In the case of the two welds made by the oxyacetylene method, the base of the rail was heated to counteract warping. The same procedure was followed on the four welds repaired by the electric-arc method using preheating and postheating. In the case of the welds repaired by the electric-arc method without the preheating and postheating, each bead was well peened with a machinist hammer to minimize warping of the rail. All the welds were finished by grinding. As mentioned above the first six welds were made on 115-lb RE rail and the last four welds were made on 132-lb RE rail, using the McKay Hardalloy "32" electrode.

In the rolling-load tests the locations of the centers of the welds were arranged to be at the point of maximum flexure. A 10-in cantilever arrangement in the 12-in-stroke rolling-load machine was used. A 48,000-lb load was applied for the 115-lb RE rail, and a 60,000-lb load was used for the 132-lb RE rail. In this type of test 2,000,000 cycles without failure are considered a run-out. All of the welds were checked ultrasonically for defects. Test No. A–1 gave a defect indication and failed in the area indicated.

The results of these tests are shown on Table 1. The oxyacetylene welds had the best results, in that one ran to 2,000,000 cycles without a failure and the other ran to 589,000 cycles, failing from a detected inclusion. The electric-arc welds failed prematurely at 49,000 to 159,000 cycles. Typical fractures of welds using both electrodes are shown on Figs. 1 and 2. The location of the fracture in the weld area may be noted on Figs. 3 to 8.

The microscopic examination of fractures revealed that a sharp line of demarcation between the weld metal and rail metal existed as well as very fine porosity on the interface. This porosity in all of the electric-arc welds was the cause of the failure. These failures were not due to excessive hardness of the weld metal, as can be noted on Table 2 showing a Brinell hardness number survey of the rail and weld metal. The hardness of the work-hardened weld metal was well within the range of the hardness of the rail metal.

It is interesting to note that the microscopic porosity in the interface could not be detected ultrasonically whereas the indication of the inclusion in Test No. A–1 was very definite. The failures of all these electric welds were due to the lack of diffusion between the weld metal and the rail as well as the porosity. The postheating lowered the hardness of the weld metal in each case but made no appreciable difference in the quality of the weld.

TABLE 1

ROLLING-LOAD TEST RESULTS OF WELDED ENGINE WHEEL BURNS ON RAIL SUPPLIED BY THE SEABOARD AIR LINE RAILROAD COMPANY

Test No.	Welding Method	Electrode or Rod	Weld Treatment	Rail Sect.	Wheel Load lb.	Number of Cycles	Remarks
A-1	Oxyacetylene	M W Rod	Base Heated	115 RE	48,000	589,700	Fracture in center of the weld from inclusion. Inclusion detected ultrasonically.
A-2	Oxyacetylene	M W Rod	Base Heated	115 RE	48,000	2,000,000	No failure - run out.
B-1	Electric Arc	3/16" McKay Frogalloy "C"	Preheat to 1000° F. Postheat to 1000° F. Base Heated.	115 RE	48,000	91,000	Fracture 1" from end of weld in the weld metal from porosity.
B-2	Electric Arc	3/16" McKay Frogalloy "C"	Preheat to 1000° F. Postheat to 1000° F. Base Heated.	115 RE	48,000	131,600	Fracture 4" from end of weld in the weld metal from porosity.
C-1	Electric Arc	3/16" McKay Frogalloy "C"	Each bead well peened.	115 RE	48,000	159,900	Fracture in center of weld from porosity.
C-2	Electric Arc	3/16" McKay Frogalloy "C"	Each bead well peened.	115 RE	48,000	88,200	Fracture in center of weld from porosity.
2-A-1	Electric Arc	McKay Hardalloy "32"	Preheat to 1000° F. Postheat to 1000° F. Base Heated.	132 RE	60,000	99,700	Fracture 1" from end of weld in the weld metal from porosity.
2-A-2	Electric Arc	McKay Hardalloy "32"	Preheat to 1000° F. Postheat to 1000° F. Base Heated.	132 RE	60,000	111,100	Fracture 1" from end of weld in the weld metal from porosity.
2-B-1	Electric Arc	McKay Hardalloy "32"	Each bead well peened.	132 RE	60,000	169,600	Fracture 1" from end of weld in the weld metal from porosity.
2-B-2	Electric Arc	McKay Hardalloy "32"	Each bead well peened.	132 RE	60,000	49,800	Fracture 1" from end of weld in the weld metal from porosity.

TABLE 2

BRINELL HARDNESS SURVEY OF WELDED ENGINE-WHEEL BURNS
USED IN ROLLING-LOAD TEST FOR THE
SEABOARD AIR LINE RAILROAD COMPANY

Test No.	Electrode or Rod	Brinell Hardness Number		
			Weld Metal	
		Rail Work Hardened	Before Work Hardening	Work Hardened
A-1	M W Rod	293	277	315
A-2	M W Rod	297	298	311
B-1	McKay Frogalloy "C"	298	217	258
B-2	McKay Frogalloy "C"	295	266	286
C-1	McKay Frogalloy "C"	293	284	290
C-2	McKay Frogalloy "C"	286	290	297
2-A-1	McKay Hardalloy "32"	321	259	269
2-A-2	McKay Hardalloy "32"	317	255	277
2-B-1	McKay Hardalloy "32"	321	302	332
2-B-2	McKay Hardalloy "32"	321	313	321

Fig. 1—Typical fracture of failed welded engine-wheel burn showing lack of diffusion between weld and rail metal, as well as porosity.

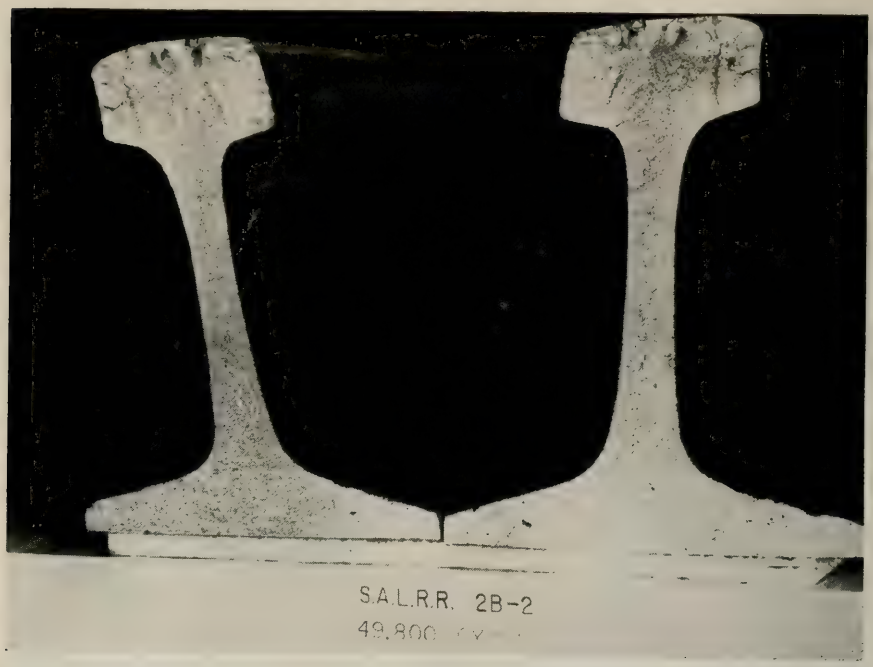

Fig. 2—Typical fracture of failed welded engine-wheel burn showing lack of diffusion between weld and rail metal as well as porosity.

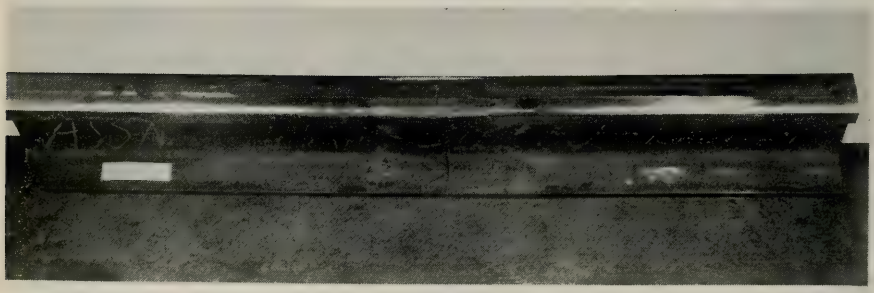

Fig. 3—In rolling-load test No. A–1 the welded engine-wheel burn failed from an inclusion. Maintenance-of-way welding rod was used.

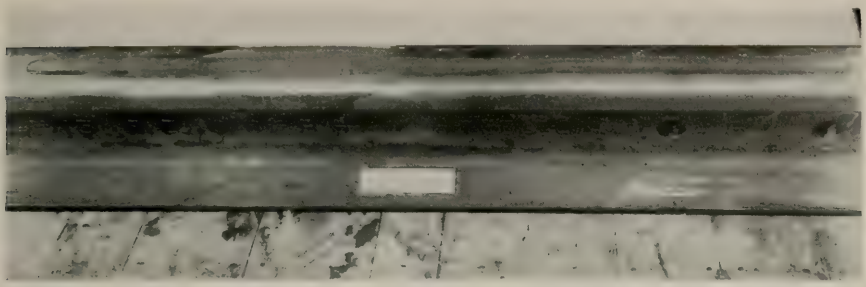

Fig. 4—In rolling-load test No. A–2 the welded engine-wheel burn ran 2,000,000 cycles, considered a run-out. Maintenance-of-way welding rod was used.

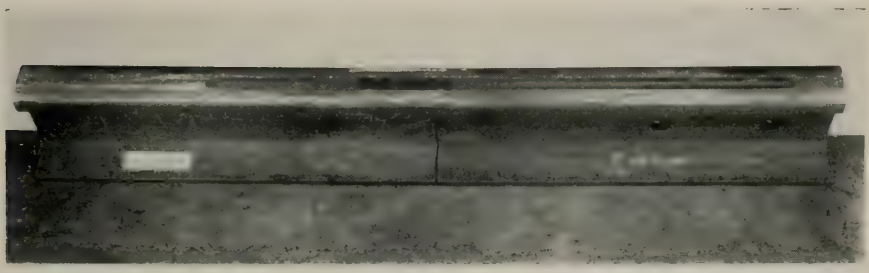

Fig. 5—In rolling-load test No. B–1 the welded engine-wheel burn failed from porosity. McKay Frogalloy "C" electrode, with preheat and postheat.

Fig. 6—In rolling-load test No. C–1 the welded engine-wheel burn failed from porosity. McKay Frogalloy "C" electrode, with no preheat and no postheat.

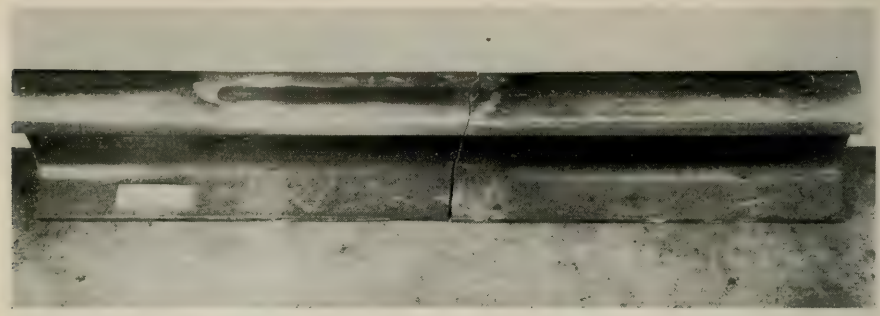

Fig. 7—In rolling-load test No. 2–A–2 the welded engine-wheel burn failed from porosity. McKay Hardalloy "32" electrode, with preheat and postheat.

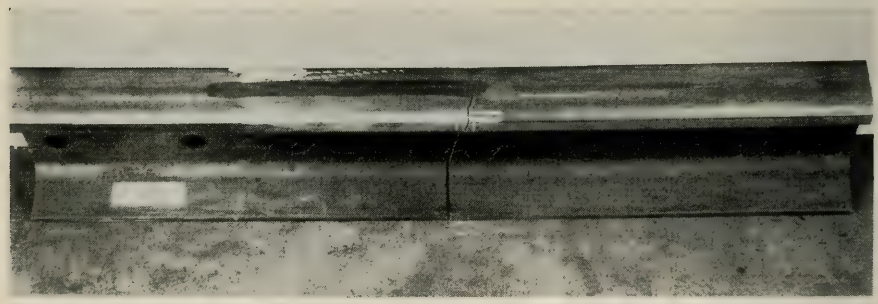

Fig. 8—In rolling load test No. 2–B–2 the welded engine-wheel burn failed from porosity. McKay Hardalloy "32" electrode, with no preheat and no postheat.

Report of Special Committee on Continuous Welded Rail

F. L. Rees, *Chairman,*
W. J. Jones, *Vice Chairman,*
R. E. Dove, *Secretary,*
Frank Aikman, Jr.

S. H. Barlow
C. N. Billings
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C. O. Conatser
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A. G. Ellefson
D. T. Faries
R. J. Gammie*
W. E. Gardner
H. F. Gilzow
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J. B. Hartranft
R. A. Hostetter
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T. P. Polson
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R. C. Postels
E. F. Salisbury
W. J. Savage
R. A. Sharood
R. A. Shaw
T. C. Shedd, Jr.
C. E. Weller
R. P. Winton
Edward Wise, Jr.**
Committee

* Died October 19, 1959.
** Died August 30, 1959.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Fabrication.

   Progress report, presented as information ..... page 898

2. Laying.

   Progress report, presented as information ..... page 926

3. Fastenings.

   The committee is continuing the study of the type and number of anti-creeping devices required for welded rail and will make recommendations in 1961.

4. Maintenance.

   Progress report, presented as information ..... page 927

5. Economics.

   Progress report, presented as information ..... page 931

6. Welding second-hand rail.

   The committee will present a report on welding of second-hand rail and the utilization of second-hand welded rail a year hence.

The Special Committee on Continuous Welded Rail,
F. L. Rees, *Chairman.*

AREA Bulletin 556, February 1960.

IN MEMORIAM

Edward Wise, Jr.
R. J. Gammie

This committee had the misfortune of losing two elder statesmen in 1959, Edward Wise, Jr., engineer maintenance of way, Louisville & Nashville Railroad and R. J. Gammie, retired chief engineer, Texas & Pacific Railway. The deaths of these two gentlemen created gaps in the committee that will be hard to close, and their guidance and suggestions will be greatly missed. Men of their caliber appear too infrequently.

Mr. Wise joined the AREA in 1940 and participated in committee activities from 1940 until his death on August 30, 1959. He served on Committee 1 from 1945 to 1949, Committee 22 from 1940 to 1952, and Committee 4 and this committee from 1952 until his passing. Within this committee he was chairman of Subcommittee 3—Fastenings.

Mr. Gammie's affiliation with the AREA began in 1916. He gave unstintingly of his time to the organization, both in committee work and in the direction of the Association. He served on Committee 27 from 1931 to 1935 and on this committee since 1952. Committee 22 was also honored by his presence from 1948 until his death. Mr. Gammie was vice chairman of Committee 22 in 1951, chairman 1952–54 and was elected Member Emeritus August 7, 1959.

Report on Assignment 1

Fabrication

J. B. Hartranft (chairman, subcommittee), S. H. Barlow, C. N. Billings, J. D. Case, L. S. Crane, W. E. Gardner, W. J. Jones, A. S. McRae, C. E. Morgan, Wm. Nuetzel, F. L. Rees, R. P. Winton.

At the request of B. R. Meyers, vice president and chief engineer of the Chicago & North Western Railway, the AAR Research Center conducted tests to determine the effect of removing the bulge from the bottom of the rail base on the strength of acetylene pressure butt welds. The report on these tests is presented herewith as Appendix A.

At the request of the Special Committee on Continuous Welded Rail, the AAR Research Center made a study of the possible effects on acetylene pressure butt welds of eliminating the normalizing process that has been generally used. The report on this study is presented herewith as Appendix B.

The Research Center authorized the Armour Research Foundation to study "Bonding of Rails" for one year. The results of this study are given herein under Appendix C.

Appendix A

Tests to Determine the Effect of Removing the Bulge from the Bottom of the Rail Base on the Strength of Acetylene Pressure Butt Welds

This is a report on tests made late in 1957 at the request of B. R. Meyers, vice president and chief engineer of the Chicago & North Western Railway, to determine the relative strength and performance of acetylene pressure welds with and without the bulge on the bottom of the rail base. The report was prepared by Kurt Kannowski, metallurgical engineer, AAR Research Center, under the general direction of G. M.

Magee, director of engineering research. Initially eight specimens were prepared for the tests at the welding plant of the railway near Chicago. These specimens were welded from 3-ft lengths sawed from two 115 RE Inland rails, and welded in the normal fashion. On four of the specimens (from rail 34623–E–5) the bulge was left on the base in accordance with the usual practice, and on four of the specimens (from rail 15936–H–6) the bulge was ground off the bottom of the base to provide a flat rail base throughout the weld. A ninth specimen was cut from a 78-ft length from a previous welding run leaving the bulge on the base.

Slow bend tests were made on five of these specimens by Professor R. E. Cramer at the University of Illinois. The results are given in Table 1. Specimen A48 was the one

TABLE 1

BEND TEST RESULTS OF PRESSURE BUTT WELDED RAIL FROM C&NW
INLAND STEEL COMPANY - 115 RE RAIL

Specimen Number	Kind of Specimen	Head or Base Down	Maximum Load Before Fracture lbs.	Energy for Fracture Ft.-lb.	Deflection at Fracture in.	Remarks
A-40	115 lb. std. rail C&NW Bulge on acetylene weld	B	350,800	55,400	2.3	Broke at weld line 65% of fractured area fused*
A-41	115 lb. std. rail C&NW Bulge on acetylene weld	B	261,000	13,400	.9	Broke at weld line 50% of fractured area fused*
A-48	115 lb. std. rail C&NW Bulge on acetylene weld	B	266,000	19,200	1.2	Broke at weld line
		Average	292,600	29,300	1.47	These three welded as short specimens
A-42	115 lb. std. rail C&NW Bulge off acetylene weld	B	309,100	40,800	2.2	Broke at weld line 90% of fractured area fused*
A-43	115 lb. std. rail C&NW Bulge off acetylene weld	B	240,000	13,000	.9	Broke at weld line 80% of fractured area fused*
		Average	274,500	26,500	1.55	These two welded as short specimens

*This percentage fractured area indicated complete fusion, remaining area fused to an unknown degree.

cut from the 78-ft rail. These tests were made on supports 4 ft apart with two-point loading 6 in on each side of the weld. It will be observed that there was considerable variation in the maximum load before fracture and especially in the energy for fracture. Observation of the fractured surfaces showed smooth areas at various locations of the rail cross section, predominately in the base and web indicating that full fusion had not been obtained in the welding process.

The following tabulation gives the results obtained in drop tests at the Inland mill on the four remaining specimens (2000-lb tup, 20-ft drop). These drop tests were made by the same method used for new 115 RE rail.

DROP-TEST RESULTS OF PRESSURE BUTT-WELDED RAIL FROM C&NW, INLAND STEEL COMPANY, 115 RE RAIL, SEPTEMBER 18, 1957

Specimen	*Bulge on Base On or Off*	*No. Blows To Destruction*	*Percent Fracture Area Completely Fused**
1 A–X	On	1	50
1 B–X	On	2	70
2 A–X	Off	2	70
2 B–X	Off	1	55

* Remaining area fused to an unknown degree.

The results obtained in the drop tests were not too satisfactory, and the same lack of complete fusion was indicated in the appearance of the fractured area. Accordingly, after giving the matter further consideration, it was thought that perhaps the fact the welds were made on 3-ft lengths of rail rather than full 39-ft lengths, as is the regular practice, may have resulted in the rails not being held firmly in alinement when the pressure was applied, and this might have resulted in incomplete fusion, particularly in the web and base. Accordingly, arrangements were made to have an additional set of weld specimens prepared, using a 39-ft length of rail on each side of the weld to insure good gripping in the machine and removing the bulge from every other weld so that corresponding test specimens with the bulge on and bulge removed would be made from the same rails. Drop tests and slow bend tests were completed on this second group of specimens. Table 2 gives the results of the slow bend tests.

It will be noted that the results obtained in the slow bend tests show considerably less variation in the maximum load before fracture and in the energy for fracture, except for Specimen A44. The fractured areas indicated good fusion, and the explanation for the lower strength of Specimen A44 is not known other than that it had a silvery appearance such as in an X-rayl. There does not seem to be any significant difference between the results obtained with the bulge on and the bulge off. In fact, the average loads for fracture and energy for fracture were more for the two specimens with the bulge off. This, however, was due to the fact that Specimen A44 broke at a relatively low load and energy.

The accompanying photographs show the appearance of the fracture for the three specimens that broke in the slow bend test (Specimen A45 did not break). These specimens were also made from Inland rail, and arrangements were made to have drop tests made at the Inland mill.

The following table gives the results obtained in the drop tests:

Drop-Test Results of Pressure Butt-Welded Rail from C&NW, Inland Steel Company, 115 RE Rail, December 11, 1957

Specimen	*Bulge on Base On or Off*	*No. Blows To Destruction*	*Percent Fracture Area Completely Fused**
1A	On	2	95
1B	On	5	95
2A	Off	2	90
2B	Off	1	100

* Remaining area fused to an unknown degree.

It will be noted that one specimen with the bulge on the base broke on the second blow and the other on the fifth blow. For the specimens with the bulge removed, one specimen broke on the second blow and the other broke on the first blow but not through the weld area, as will be noted from the accompanying photographs.

It would appear from these test results, therefore, that there is no appreciable difference in the strength of the acetylene pressure welds whether the bulge is left on the bottom of the base or removed by grinding. Also, a very good weld performance is indicated when welds stand up as well as they did under the drop test. The results obtained in the drop tests on these specimens with the bulge removed by grinding were much better than those obtained a year or so ago, in which tests two specimens with the bulge on withstood one or more blows before failure, but both specimens with the bulge removed by grinding broke on the first blow with little deformation. These speci-

TABLE 2

BEND TEST RESULTS OF PRESSURE BUTT WELDED RAIL FROM C&NW
INLAND STEEL COMPANY - 115 RE RAIL

Specimen Number	Kind of Specimen	Head or Base Down	Maximum Load Before Fracture lbs.	Energy for Fracture Ft.-lb.	Deflection at Fracture in.	Remarks
A-44	115 lb. std. rail C&NW Bulge on acetylene weld	B	276,000	18,300	1.1	Broke at weld line
A-47	115 lb. std. rail C&NW Bulge on acetylene weld	B	376,200	108,000	4.3	Broke 2 in. from weld line
		Average	326,100	63,100	4.7	These two welded as full length rails
A-45	115 lb. std. rail C&NW Bulge off acetylene weld	B	386,000	153,000	5.6	Did not break
A-46	115 lb. std. rail C&NW Bulge off acetylene weld	B	367,000	74,400	3.2	
		Average	376,000	113,700	4.4	These two welded as full length rails

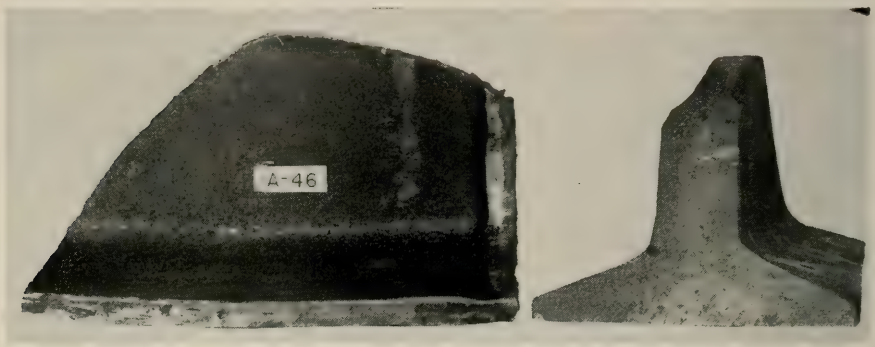
mens were obtained in connection with the laying of continuous welded rail where it was necessary to cut out welds for switches or insulated joints, and the bulge metal was ground off, therefore, several days after the welding. Although a complete investigation has not been made of this, it seems likely that better results will be obtained in the drop test if the bulge is ground off while the metal is still hot from the welding operation.

In commenting on the slow bend tests, Professor Cramer stated, "There are welding conditions which can have a much greater effect on the quality of the weld than the bulge on the base."

It is concluded from these tests that there is no significant difference in the strength of the weld, and there is no reason to expect any significant difference in the performance of the weld whether or not the bulge on the base of acetylene pressure welds is removed by grinding (while still retaining heat from welding) or left on as has been the past practice.

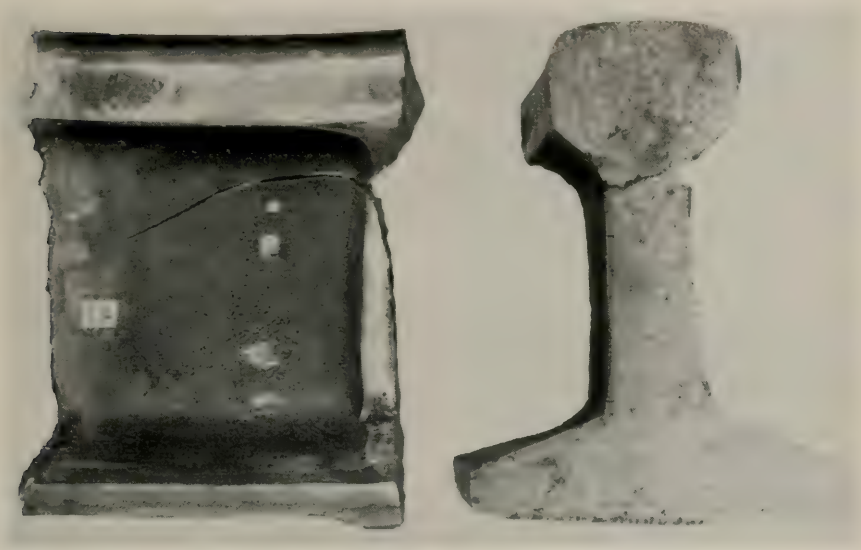
Additional tests of acetylene pressure welds with and without normalizing (see Appendix B) have been made at the Research Center for the Special Committee on Continuous Welded Rail, and the specimens for these tests were also made both with and without the bulge on the base. Slow bend tests and drop tests have been completed on these specimens, and the results are in conformity with those given above, also indicating no significant effect of removing the bulge from the rail base.

Specimen A44—Bend test, bulge on.

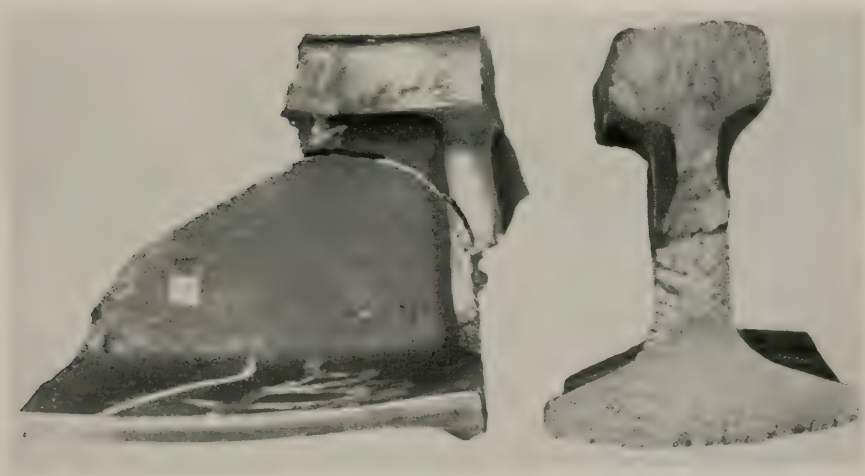


Specimen A46—Bend test, bulge off.

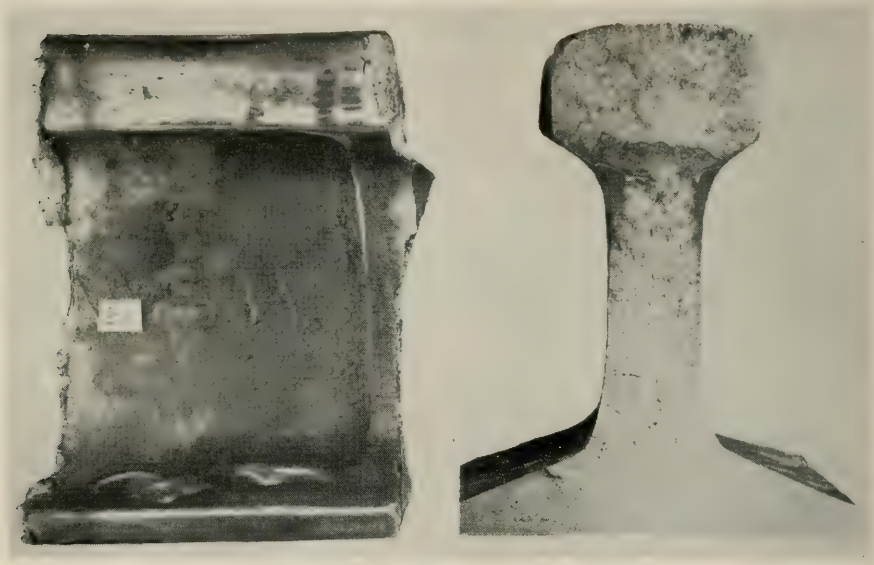
Specimen A47—Bend test, bulge on.



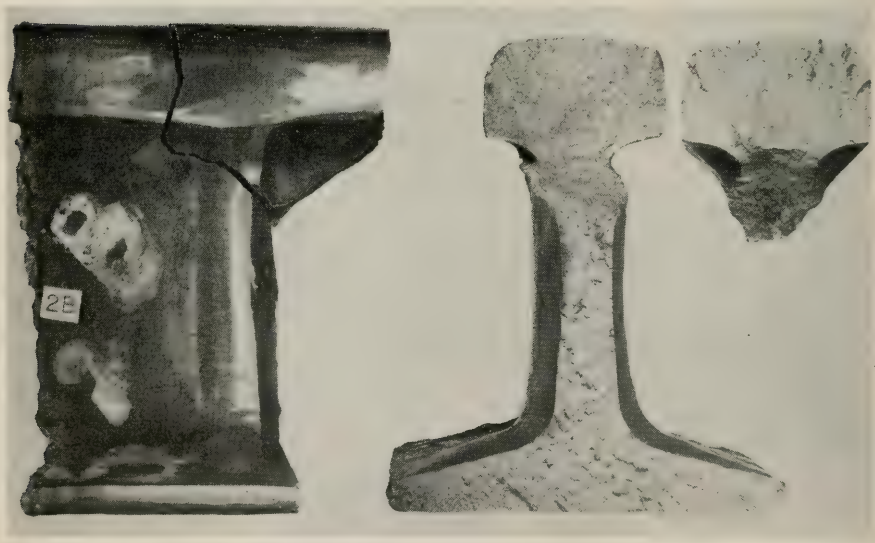
Specimen 1A—Drop test, bulge on.



Specimen 1B—Drop test, bulge on.



Specimen 2A—Drop test, bulge off.



Specimen 2B—Drop test, bulge off.

Appendix B

Physical Tests of Normalized and Not-Normalized Oxyacetylene Pressure Butt-Welded 115 RE Rail

In line with the AAR Research Center's policy of developing as much practical information as possible in regard to butt welding of rail, an investigation of normalized and not-normalized oxyacetylene pressure butt-welded 115-lb RE rail was completed and is described in this report. The results of a similar investigation on the effect of removing or not removing the upset metal at oxyacetylene butt-welded joints are presented in Appendix A.

The procedure of testing involved the making of rolling-load tests at the AAR Research Center, drop tests at the rail-producer's plant, and slow bend tests at the Talbot Laboratory of the University of Illinois. The investigation was conducted, under the general direction of G. M. Magee, director of engineering research, by Kurt Kannowski, metallurgical engineer of the Research Center staff.

The welds were made at the Chicago & North Western Railway welding plant, using three 39-ft rails, according to the normal procedure with the exception of not normalizing eight of the welds. The three rails were first welded together, then cut 6 ft from each weld. The welding was repeated until eight welds with normalizing and eight welds without normalizing had been produced. The upset metal on the bottom of the base was removed by grinding from half the welds for each condition.

The rolling-load tests conducted at the AAR Research Center were made under the loading arrangements shown on Figs. 1 and 2, using 48,000-lb and 60,000-lb wheel loads. These arrangements subject the head area of the welded rail to repeated tension from zero to the maximum. In this type of testing, 2,000,000 cycles of repeated loading without failure are considered a runout. The results of these tests are shown on Table 1.

In the first group of tests two normalized and two not-normalized welds, with upset on and with upset removed from the base, were subjected to a 48,000-lb wheel load. Three of these test specimens ran out at 2,000,000 cycles. Test specimen No. X–8, which was not normalized, failed at 608,000 cycles from a grinding crack 4 in from the weld. This can be noted on Figs. 8 and 15.

The next test group, consisitng of two normalized and two not-normalized welds, with and without the base upset, was subjected to a 60,000-lb wheel load in a 33-in rolling-load machine under the loading arrangement shown in Fig. 2. Both of the normalized specimens failed in the weld area from scale inclusions, as shown on Figs. 5, 6, 11 and 12. Test specimen No. X–3, which was not normalized, ran out. The specimen No. X–4 failed early from a grinding crack 4½ in from the weld, as shown on Figs. 4 and 14. The data from the table indicate that all the failures produced in the rolling-load tests were from causes other than the effects of normalizing or not normalizing.

The slow bend test of two normalized and two not-normalized oxyacetylene pressure butt welds were made at the University of Illinois by Professor R. E. Cramer. Each test rail, supported at points 4 ft apart, was loaded at two points, one on each side of the weld and 6 in from it. The tests were made with the rail base down. The results are shown on Table 2. They indicate a trend toward greater load, energy absorption and deflection in favor of the not-normalized tests.

The drop tests of two normalized and two-not normalized oxyacetylene pressure butt-welded rails were conducted at the Gary Works of the U. S. Steel Corporation. These tests were made the same as those specified for new 115-lb RE rail (2000-lb tup, 20-ft drop). The data are shown on Table 3. Again no significant difference can be

found in the data for the normalized compared with the not-normalized welds. Welds 1, 2 and 4 broke outside the weld area in the head. Weld 3 broke through the weld area because the base was only partially fused.

In order to develop further information, a Brinell-hardness-number survey was made of the rolling-load test specimens shown on Table 1. The Brinell hardness number was obtained on the wheel path every ½ in on both sides of the weld, continuing into the area of the rail head not in the wheel path. A portable King Brinell machine was used. These data are shown on Table 4. It is interesting to note that the heat-affected zone on normalized welds extended 4½ in on both sides of the weld and that the heat-affected zone of the not-normalized area extended 2 to 2½ in on both sides of the weld. The two failures due to grinding cracks on the not-normalized welds occurred 1½ to 2 in away from the end of the heat-affected zone. Consideration must be given to the fact that the variation of the BHN is affected by the variation in the BHN of the original rail and the sensitivity to work hardening of this metal.

The data in this report indicate that very little difference exists between normalized and not-normalized oxyacetylene pressure butt-welded rail joints. The smaller heat-affected zone of the not-normalized welds should not affect the quality or performance of the joint. It is known that the heat-affected zone of electric-flash-welded rail joints is even smaller, and this type of weld has given a satisfactory service performance. It can be noted from this report and the report presented under Appendix A that other variables affect the performance of the weld more than the practice of not normalizing.

TABLE 1

RESULTS OF ROLLING LOAD TESTS OXYACETYLENE PRESSURE BUTT WELDED 115 RE RAIL

Test No.	Type of Test	Stroke of Rolling Load Machine	Wheel Load Lb	Number of Cycles	Remarks
X-6	Upset metal on base normalized	12"	48,000	2,052,600	-------
X-7	Upset metal removed normalized	12"	48,000	2,000,000	-------
X-5	Upset metal on base not normalized	33"	48,000	2,000,000	-------
X-8	Upset metal removed not normalized	33"	48,000	608,000	Fracture 4" from weld, grinding crack.
X-1	Upset metal on base normalized	33"	60,000	171,000	Fracture in the weld scale inclusion.
X-2	Upset metal removed normalized	33"	60,000	1,033,600	Fracture in the weld scale inclusion.
X-3	Upset metal on base not normalized	33"	60,000	2,023,800	-------
X-4	Upset metal removed not normalized	33"	60,000	434,400	Fracture 4½" from the weld, grinding crack.

TABLE 2

RESULTS OF BEND TESTS OXYACETYLENE PRESSURE BUTT WELDED 115 RE RAIL

Test No.	Type of Test	Head or Base Down	Maximum Load Before Fracture Lb	Energy for Fracture Ft -Lb	Deflection at Fracture Inches	Remarks
A-49	Upset metal on base not normalized.	B	372,000	62,500	2.9	Fracture at weld line
A-52	Upset metal removed not normalized	B	342,000	48,000	2.3	Fracture at weld line
A-51	Upset metal on base normalized	B	315,000	36,700	1.8	Fracture at weld line
A-50	Upset metal removed normalized	B	339,000	51,250	2.4	Fracture at weld line

TABLE 3

RESULTS OF DROP TESTS OXYACETYLENE PRESSURE
BUTT WELDED 115 RE RAIL

Test No.	Type of Test	No. of Blows to Failure
1	Upset metal on base not normalized	2
2	Upset metal removed not normalized	1
3	Upset metal on base normalized	1
4	Upset metal removed normalized	2

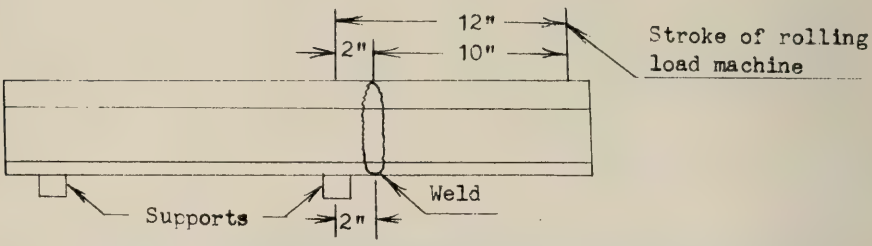


Fig. 1—Loading arrangement for rolling-load test of oxyacetylene pressure butt-welded rail, 115 RE section, 48,000-lb wheel load.

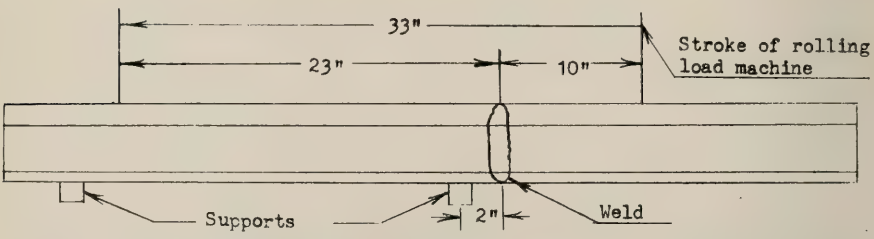


Fig. 2—Loading arrangement for rolling-load tests of oxyacetylene pressure butt-welded rail, 115 RE section, 60,000-lb wheel load.

TABLE 4. BRINELL HARDNESS NUMBER SURVEY OF OXYACETYLENE PRESSURE BUTT-WELDED 115-LB RE RAIL NORMALIZED AND NOT NORMALIZED

Test No.	Treatment	Average B.H.N.		Brinell Hardness Number																						
		Before Rolling	After Rolling	Inches from the Center of the Weld																						
				5 1/2	5	4 1/2	4	3 1/2	3	2 1/2	2	1 1/2	1	1/2	0	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2
X-1	Norm	241	286	269	269	269*	286	286	293	269	277	286	282	282	286**	282	293	293	293	302	293	302	311	293	255*	290
X-2	Norm	269	302	321	311	289*	324	337	332	332	324	317	311	337	344**	321	306	293	311	321	321	321	311	282*	302	302
X-6	Norm	273	300	262	266	248*	261	277	289	286	297	282	315	351	321	335	286	298	311	313	315	317	317	282*	286	300
X-7	Norm	269	286	268	279	269	252*	298	302	298	295	293	300	302	302	311	302	298	300	306	311	311	306	274*	286	286
X-3	Not Norm	255	289	292	297	293	289	290	298	298	275*	309	298	298	302	289	319	311	279*	295	302	309	302	302	300	298
X-4	Not Norm	255	277	337	311	293	309	317	311	293*	306	340	340	337	317	311	311	302	282*	298	306	302	293**	286	290	273
X-5	Not Norm	245	281	286	282	286	286	286	286	284	258*	297	311	286	297	324	317	307	275*	281	284	286	282	286	287	282
X-8	Not Norm	262	292	302	307	302	313	321	306	300	286*	334	317	315	340	334	273	313	307	286*	306	302	298**	306	306	307

* End of heat affected zone. **Location of rail break.

Fig. 3—Rolling-load test No. X–3, oxyacetylene pressure butt-welded 115 RE rail, 60,000-lb wheel load, not normalized.

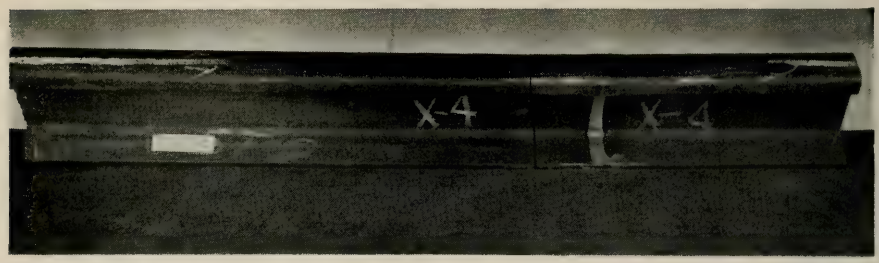


Fig. 4—Rolling-load test No. X–4, oxyacetylene pressure butt-welded 115 RE rail, 60,000-lb wheel load, not normalized.

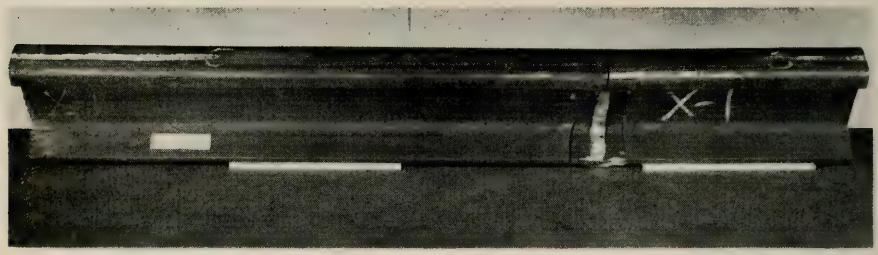


Fig. 5—Rolling-load test No. X–1, oxyacetylene pressure butt-welded 115 RE rail, 60,000-lb wheel load, normalized.

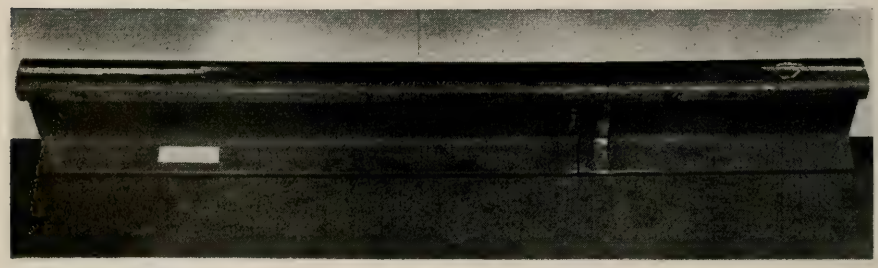


Fig. 6—Rolling-load test No. X–2, oxyacetylene pressure butt-welded 115 RE rail, 60,000-lb wheel load, normalized.

Fig. 7—Rolling-load test No. X–5, oxyacetylene pressure butt-welded 115 RE rail, 48,000-lb wheel load, not normalized.

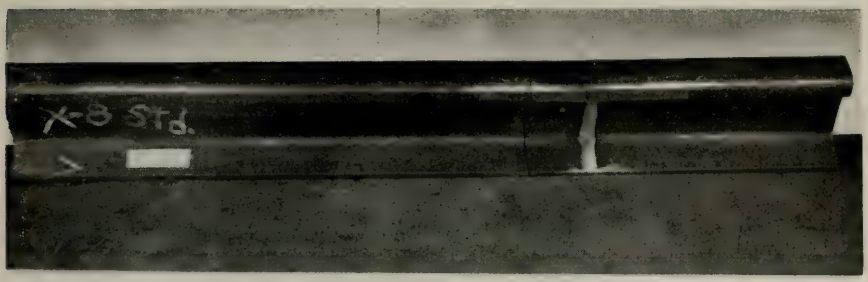


Fig. 8—Rolling-load test No. X–8, oxyacetylene pressure butt-welded 115 RE rail, 48,000-lb wheel load, not normalized.

Fig. 9—Rolling-load test No. X–6, oxyacetylene pressure butt-welded 115 RE rail, 48,000-lb wheel load, normalized.

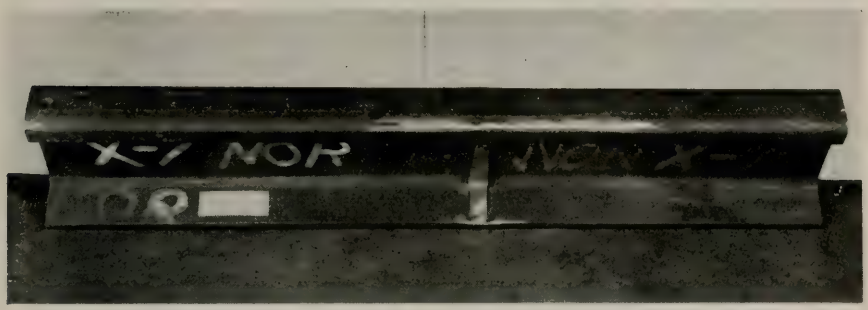


Fig. 10—Rolling-load test No. X–7, oxyacetylene pressure butt-welded 115 RE rail, 48,000-lb wheel load, normalized.

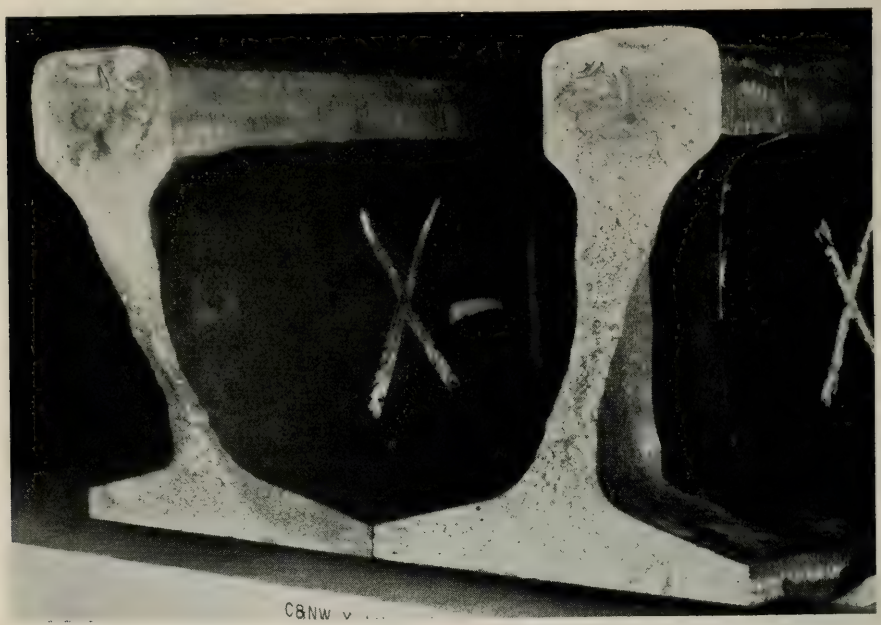


Fig. 11—In rolling-load test No. X–1, failure occurred in the weld area from a scale inclusion, 60,000-lb wheel load, normalized.

Fig. 12—In rolling-load test No. X–2, failure occurred in the weld area from a scale inclusion, 60,000-lb wheel load, normalized.

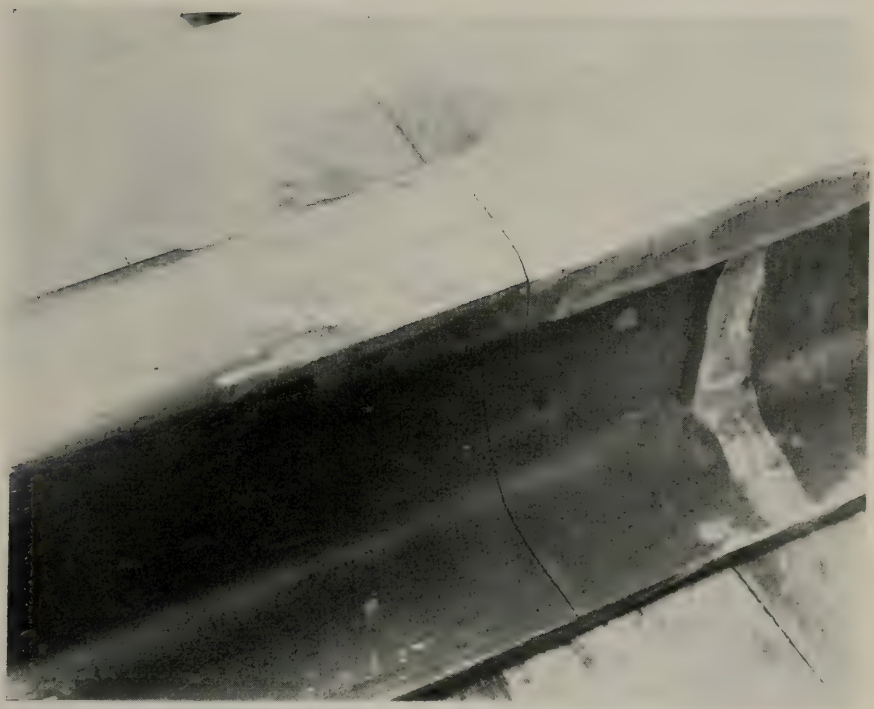


Fig. 13—Typical failure from a grinding crack.

Fig. 14—Failure due to a grinding crack in rolling-load test No. X–4, 60,000-lb wheel load, not normalized.

Fig. 15—Failure due to a grinding crack in rolling-load test No. X–8, 48,000-lb wheel load, not normalized.

Appendix C

Bonding of Rails

(Armour Research Foundation Project No. B 726)

A. ABSTRACT

A program has been carried out to determine the feasibility of using various diffusion bonding or brazing techniques to join railroad rails metallurgically without the disadvantages of having to remove the upset or flash from conventional pressure or flash welds. Joints were made by conventional brazing and by a newly developed metal fiber shim brazing technique in 132-lb RE rail. These joints had strengths up to 71,800 psi maximum tensile fiber stress at failure in a static bending test. This compares to acceptability values for conventionally welded rail by one railroad of 140,000 psi for relayer rail and 160,000 for new rail.

Several improvements in the metal fiber shim brazing method are discussed, and it is proposed to develop this method further in the hope of accomplishing the desired objective.

B. INTRODUCTION

Today rails are joined by welding in ever-increasing amounts. The general term "welding" is used to include several joining methods: electric-flash, gas-fusion, and thermit welding. It is general practice to weld 1000 ft or more of rails together at a welding station and transport the continuous rail to a site for laying. One inherent disadvantage is common to the above three methods—the resultant joints have considerable upset, flash, or cast material which has to be subsequently removed. This cleaning operation adds to the cost of the weld per joint.

A process was sought whereby a metallurgical joint could be obtained without having to contend with excess metal build-up and removal. As a process, brazing or diffusion bonding has the advantage that no excess or upset metal is produced. The purpose of this project was to investigate the feasibility of utilizing brazing or diffusion bonding for joining railroad rails.

Brazing is defined as a process of joining base metal with the use of a nonferrous filler material which has a melting point lower than that of the base metal. The filler material can either be preplaced or flowed into the joint. For present purposes, diffusion bonding may be defined as a variation of brazing in which all the filler metal diffuses into the base metal during the bonding operation so that no discrete joint is discernible.

The variables investigated included end clamping pressure, gas pressure, torch tip sizes, heating rate, temperature distribution, and joint filler materials.

C. MATERIALS

The rails joined in this project were 132-lb RE. The rail sections were 6 ft in length, and the mating surfaces were prepared by an abrasive cut-off wheel. The nominal chemical composition for these rails is: carbon 0.69–0.82; manganese, 0.70–1.00; phosphorus, 0.04 max; silicon, 0.10–0.23. The properties and principal dimensions of the rail are: height, 7⅛ in; width of base, 6 in; section modulus, 27.6 in ^{3}. A discussion of the filler materials is presented in a later section.

D. APPARATUS AND EQUIPMENT

For this rail-joining program a conventional oxyacetylene pressure welding machine was kindly loaned to the Foundation by the Linde Company. The welding machine is

equipped with hydraulic pump and rams for holding and applying clamping pressure to the rail sections; four water-cooled heating heads, having some 125 torch tips with orifice sizes varying from 54 to 72 (drill sizes) and lengths for $\frac{11}{16}$ to $\frac{15}{16}$ in; a mechanism for oscillating the heating heads across the joint of the mating rails; a pump for circulating cooling water through the heating heads; and individual gages and valves to regulate the oxygen and acetylene pressures. The respective gas lines to the machine are supplied from five cylinders each through a manifold arrangement.

A 16-point temperature-indicating recorder measured the temperature distribution in the cross section of a 2-ft length of solid rail.

Tensile machines were used to perform the static bend tests on the bonded specimens.

A rapid portable electroplater was employed to plate the rail ends with various thickness of copper (see Fig. 2).

E. EXPERIMENTAL PROCEDURE

The general method of joining the rails remained the same throughout the project. Prior to joining, the rail ends were cleaned with carbon tetrachloride to remove any grease or dirt. A filler material was placed between the mating surfaces, and the proper clamping pressure was applied. This pressure was maintained through the heating cycle and until the specimen had cooled.

After a specimen was made and fractured, the other two ends were used as mating surfaces, thus eliminating the necessity for a large number of rails. Later, both ends of the original 6-ft sections were given new joining surfaces by the abrasive cut-off machine.

1. General Bonding Parameters

Bonding parameters were established by a systematic investigation of such variables as joint fillers, clamping pressure, tip sizes, gas pressures, and heating time.

a. *End Clamping Pressure*

In spite of the fact that the rail ends were prepared by cutting with an abrasive wheel, this did not assure perfect mating of the surfaces during bonding, because of the flexing of the wheel during cutting. Therefore, sufficient end clamping pressure was applied during bonding to cause a slight upset and close any open spaces at the faying surfaces.

b. *Rail Joint Heating*

Such data as were available in regard to heating for pressure welding were used as the starting point for choosing tip sizes, gas pressures, and torch-bank movement. After several joints were made and fractured with a sledge hammer, it was apparent that non-uniform temperature distribution was the reason for the low bond strengths. The temperature distribution across the rail cross section was determined with the use of thermocouples imbedded for a depth of 9 in into the cross section of a 2-ft length of rail. Optimum tip sizes, gas pressures, length of heating zone, and heating time were then established to produce uniform temperature distribution. This is illustrated in Fig. 1.

c. *Filler Materials*

The joint filler materials investigated are listed in Table 1 and discussed below.

(1) Copper

Bonded specimens were made using one or more thicknesses of copper foil 0.00075 in thick, and/or electroplated copper. Plating was accomplished with the portable electro-

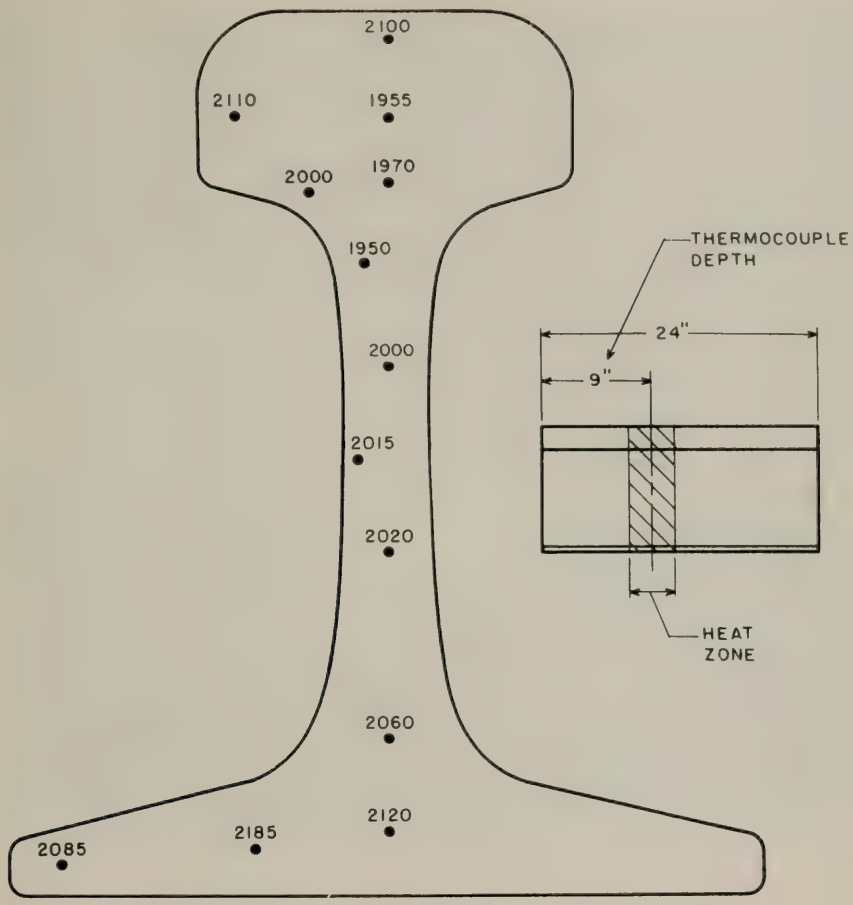


Fig. 1—Temperature distribution on rail section.

plater as shown in Fig. 2. A plating time of 5 min was required to deposit approximately 0.0001 in of copper on a rail surface.

(2) Commercial Brazings Alloys and Other Filler Materials

Commercial "Nicrobraze 50" 97 percent Ag—3 percent Li brazing alloys, and brass were investigated as possible filler materials. A commercial paste flux and/or a commercial gas flux was used in conjunction with these filler metals, which were in sheet form and used with and without copper-plated rail ends.

(3) Mild Steel Fiber Metal Shims

A unique method of applying filler metal was investigated involving the use of fiber metal shims. Fiber metallurgy is a Foundation development which has been shown on this program to be an excellent method of disposing filler metal in a brazed joint.

The process consists of suspending short lengths (⅛ to ½ in) of metal fibers in glycerine, stirring the mixture to be sure that the fibers take a random orientation and

Fig. 2—Copper plating a rail end with portable electroplater.

are dispersed, then felting the fibers to produce a porous body. The body is then pressed to any desired density and thickness, and sintered. The porous body can then be impregnated with the lower-melting filler material, and this impregnated shim placed within the joint gap between the rail ends. In theory, this approach has excellent promise for joining rails since the bond can exist from one rail end through a mat of steel fibers to the other end, all of which is reinforced with a filler alloy such as copper. Furthermore, the fiber metal shim, either impregnated or not, is compressible during the bonding operation; it therefore serves to take up any surface irregularities or mismatch of the rail ends.

Several variations of this approach were practiced in this program: (1) An unimpregnated fiber shim only, with no filler metal; (2) plated or unplated rail ends, one or more thicknesses of filler metal foil placed on both sides of the fiber metal shim which has not been pre-impregnated. The shims were, in all cases, 10 percent dense and 0.030 in thick. It was originally felt in using approach (2) that the molten copper would fill the void areas in the fiber shim during the bonding operation. This did not prove to be the case, however, since it was determined that the 10 percent dense fiber metal

Fig. 3—Fractured rail joint after two-point-loading bent test. Joint filler material was a mild-steel fiber metal shim.

shim was compressed to 100 percent density during the heating operation before the copper melted. Therefore, in future work, the fiber shim will be impregnated with the filler alloy before bonding.

2. Strength Testing

The strength of bonded rail joints was determined by subjecting the specimens to one or two-point-load static bend tests, with the rail head up. The load was applied until the joint fractured. The two-point-load static bend test was performed on specimens 6 ft long with the supports 2 ft each side of the weld and the two loading points 6 in each side of the weld. The majority of the bonded specimens were tested with one-point loading. These specimens were initially 12 ft long, but became shorter as the fractured ends were cut off and subsequently joined to form a new specimen.

Results of the bend tests are given in the form of values of fracture load; as well as values of maximum unit tensile fiber stress at the rail bottom, which was computed by dividing the applied bending moment by the section modulus of the rail.

TABLE I

RESULTS OF RAIL BONDING

Joint Material	Initial Joint Thick., in.	Rail Clamp Pressure, psi	Heating time, min	Bend Test Fracture Load, lb.	Max. Unit Tensile Fiber Stress, psi ($S_t = M_c/I$)
Cu plating only	0.0002	610	5	Sledge hammer	-
		610	6	50,000	27,200
		1840	8	Sledge hammer	-
		610	6.5	Sledge hammer	-
		1000	7	53,000	28,800
		610	7	55,000	29,900
		1220	5	Sledge hammer	-
		1220	10	Sledge hammer	-
		610	8	58,200	31,600
		1840	8	69,600	37,800
		1840	7.5	78,000	42,400
		1840	7	84,000	45,600
		1840	7	77,600	42,100
Cu foil, 1 thickness	0.00075	610	7	Sledge hammer	-
		1840	7	Sledge hammer	-
		1840	7	65,400	35,500
Cu plating plus 1 thickness Cu foil	0.00095	610	8	65,000	35,300
		1220	6.5	Sledge hammer	-
		1220	9	80,000	43,500
		1840	8	85,000	46,100
		1220	10	82,000	44,500
		1220	10	94,000	51,000
		610	7	72,000	39,100
		1840	7	80,000	43,500
Cu plating plus 2 thicknesses Cu foil	0.00170	1840	7.5	114,000	62,000
Cu plating plus 4 thicknesses Cu foil	0.0032	610	7	94,000	51,000
		1840	8	88,000	47,800
		1840	7	89,000	48,300
		1840	7	93,400	50,600
Cu plating plus 8 thicknesses Cu foil	0.0062	1840	6	108,000	58,600

F. RESULTS AND DISCUSSION

The results of the program are shown in Table 1.

1. Bonding Parameters

For most of the program the clamping pressure holding the rails in contact during bonding was 1840 psi, which yielded about ¼ to ½ in of upset. Rail bonding was accomplished in about 7 min of heating time, and the average length of the heating zone was 5 in. Acetylene gas pressure on the four heating heads was 7 psi. The oxygen gas pressures in psi for the top, web, and base heads were 18, 22, and 20, respectively.

TABLE I (continued)

RESULTS OF RAIL BONDING

Joint Material	Initial Joint Thick., in	Rail Clamp Pressure, psi	Heating time, min	Bend Test Fracture Load, lb	Max. Unit Tensile Fiber Stress, psi ($S_t = M_c/I$)
Cu plating plus 4 thicknesses brass	0.0042	1840	6	88,600	48,100
Nicrobraze "50" brazing alloy, 1 thickness	0.0050	1840	7	Fractured on cooling	-
Mild steel fiber shim only	0.030	1840	6	100,800	54,600
		1840	7	+	-
		1840	7	93,600	50,800
		1840	6	220,000*	71,800
97% Ag-3% Li Brazing alloy plus 0.008 in fiber shim	0.004	1840	6	73,000	39,600
Cu plating plus 0.030 in fiber shim plus 4 thicknesses Cu foil		1840	7.5	117,700	63,900
	0.0332	1840	7	103,600	56,200
		610	7	76,400	41,500
		1840	7	98,000	53,200
		1840	7	83,000	45,100
		1840	7	98,000	53,200
		1840	7	+	-
		1840	7	142,700*	46,500

+ Sectioned for metallography

* Two-point loading static bend test

2. Joint Strengths as Influenced by Filler Materials

Of the various filler materials investigated, the strongest joint having a maximum fiber stress of 71,800 psi, was exhibited by a bond made with a fiber metal shim only. This specimen after testing is shown in Fig. 3. A joint made with copper-plated ends, plus a fiber shim, plus several thicknesses of copper foil, and a joint made similarly but without the fiber shim were the next strongest, 63,900 psi and 62,000 psi. It is not possible to conclude from the data whether one- or two-point loading made any difference; the rails bonded with the plated ends, fiber shim, and several thicknesses of copper foil failed at about the same maximum fiber stress, independent of whether the loading was one- or two-point.

Considering only those rails bonded at a clamping pressure of 1840 psi, it can be seen that strength rises with joint thickness. The lowest strengths, 35,000 to 46,000 psi, were exhibited by the bonds made with copper plating only, one foil thickness only, or copper plating plus one thickness of foil. The strongest joints, up to 71,800 psi, were the thicker ones, as discussed above.

It is possible to conclude from this that in spite of the theoretical desirability of a diffusion-bonded joint, which is more likely to be attained in a thin joint than in a thick joint, the practical factors of end preparation, fit-up, and non-uniformity of heating due to size and non-uniform cross section preclude the possibility of achieving a sound diffusion bond over the entire cross section of the rail. Providing a means for accommodating these irregularities is imperative.

Continuing this line of reasoning, the means can be either a conventional brazed joint, which attained some of the highest strengths on this program, or the use of the pre-impregnated fiber metal shim. Of the two, the second is the more promising: Firstly, joint strength would have to be increased 2 or 2½ times to be competitive with that of conventionally welded rail according to one source.* The likelihood of achieving this improvement in a relatively thick, conventionally brazed joint is remote. However, the likelihood of effecting vast improvement in strength for joints utilizing fiber metal shims is excellent for the following specific reasons: (1) The fiber metal shims in this study were made of mild steel for reasons of availability and just to determine the feasibility of the idea. This in itself constitutes a plane of weakness in the rail, which can be avoided by using rail steel fiber shims; these can be obtained with not much more difficulty than mild steel shims, now that their desirability is known. (2) Because of the compressibility of a fiber metal shim, it is ideal for compensation of surface non-parallelism, either gross or fine, arising from mechanical or thermal causes, *provided* that the variable size interstices between the fibers over the entire shim are filled with copper brazing filler alloy. As was learned from metallographic examination (discussed later in this report), this was not the case on any of the bonds made on this program. The necessity for pre-impregnating the shims was realized soon enough, and it was erroneously thought that placing several thicknesses of copper foil on either side of the fiber shim would provide molten copper at the bonding temperature that would fill the shim interstices. The fallacy in this reasoning is that during heating, the originally 10 percent dense shim was compressed to substantially 100 percent density by the rail clamping pressure before the melting point of copper had been reached. Therefore, when the copper melted, there were no interstices or capillaries left to impregnate.

The type of joint resulting from using a rail steel fiber shim, pre-impregnated with copper, would be a copper brazement varying in thickness to entirely fill the joint gap between rail ends, with the copper reinforced by the fine network of sintered rail steel fibers. By such a scheme, it is not at all unreasonable to hope for an increase in joint strength 2½ times over that reported in Table 1.

3. Metallographic Studies

The microstructures of the various sections in a joint containing a mild steel fiber metal shim only as filler material is shown in Fig. 4. The joint thickness varies to some extent over the cross section of the rail. The thickness is seen to be about 0.003 in, which corresponds to the 100 percent density of the shim which originally was 0.030 in thick and 10 percent dense. Some porosity is evident, as is the lower carbon content of the fiber material. The bond at the surface of the rail is not sound, the fiber shim in this region probably having been melted out. Microstructures in Fig. 5 are for a joint made with copper-plated rail ends, four thicknesses of copper foil, and a 10 percent dense 0.030-in-thick mild steel fiber metal shim. These structures also show some variation of the cross section of the joint. In some areas copper has penetrated the grain boundaries

* A private communication from C. J. Code of the Pennsylvania Railroad states that they expect a strength of 160,000 psi in welded new rail, and 140,000 psi in welded relayer rail.

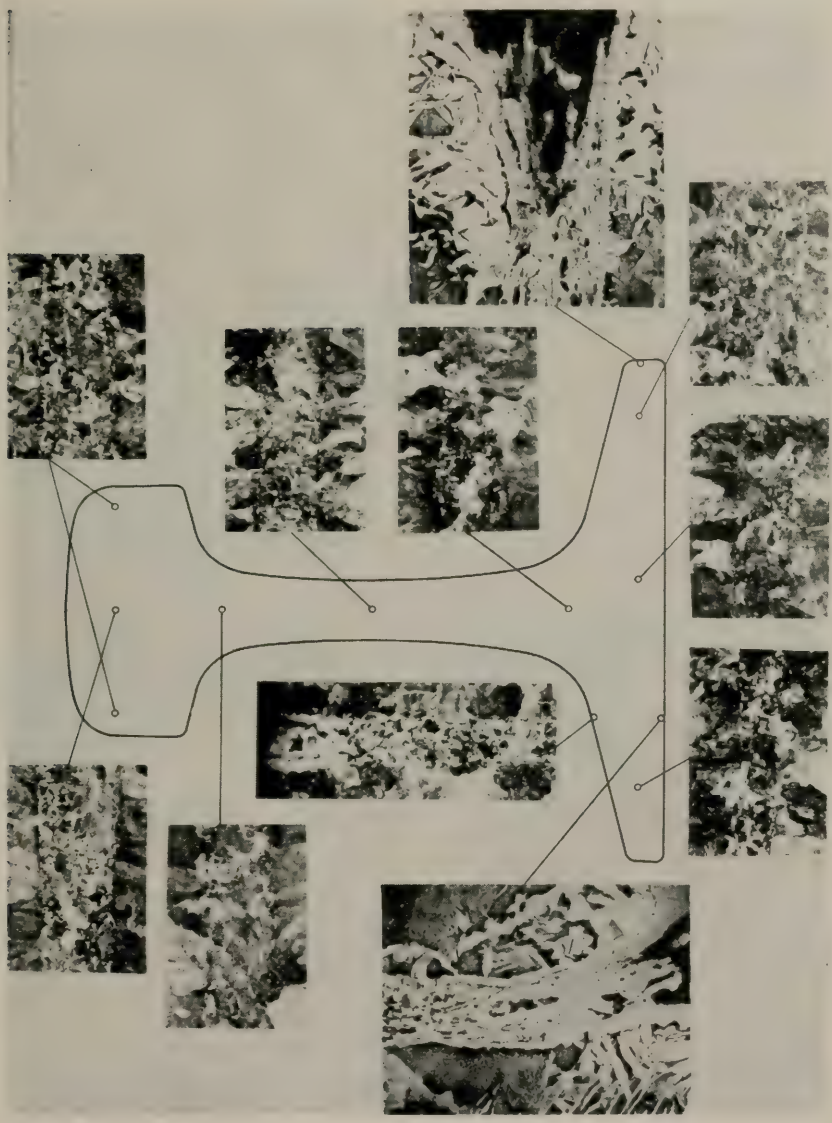


Fig. 4—Microstructures of rail joint. Filler material is pre-placed mild-steel fiber metal shim. (Magnification about 180×).

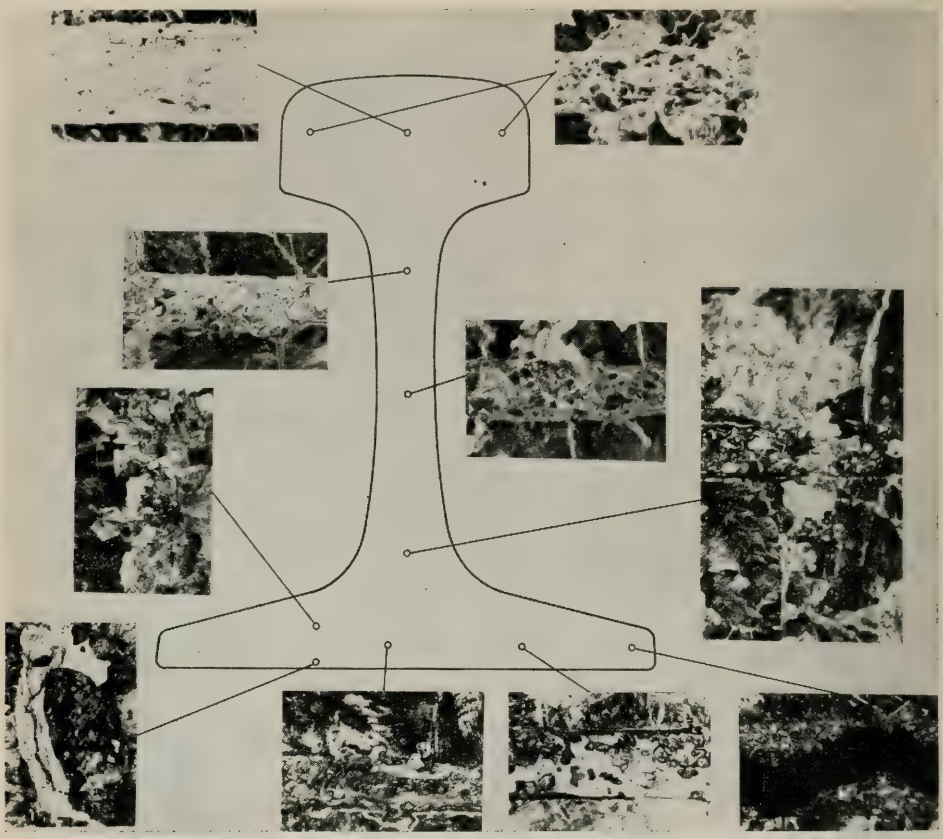


Fig. 5—Microstructures of rail joint. Filler material is pre-placed mild-steel fiber metal shim and copper foil. (Magnification about 180×).

of the steel. In some areas, notably in the center of the head section, a relatively wide band of copper separates the compressed fiber metal shim and the rail ends, and there is practically no infiltration of copper into the fiber shim. This indicates that the fiber shim has been compressed to 100 percent density before the copper melted. The right side of the base is completely unbonded.

G. CONCLUSIONS

1. The strength in static bending of rails bonded by conventional brazing or by a unique brazing technique involving the use of fiber metal shims ranges up to a maximum tensile fiber stress at failure of 71,800 psi. This compares to acceptability values for conventionally welded rail by one railroad of 140,000 psi for relayer rail and 160,000 psi for new rail.

2. The advantages and feasibility of bonding rail using porous fiber metal shims with or without additional brazing filler metal has been shown. Work to date has been done using mild steel fiber metal shims, with and without copper foil on either side of

the shim to supply molten filler metal. Since this technique yielded a joint strength as high as 63,900 psi, the superior technique of employing rail steel fiber metal shims pre-impregnated with copper could yield strengths comparable to those of pressure-welded rail.

3. The practical factors of surface finish, mismatch, and nonuniform temperature distribution during heating of the rail defeat the possibility of using a pure diffusion bonding approach in which the filler metal is diffused into the base metal during bonding, leaving no discrete joint.

H. RECOMMENDATION FOR FURTHER INVESTIGATION

As developed in this report, and based upon the findings of this initial investigation, the best possibility for making a strong metallurgical joint in railroad rail, without having to remove the heavy upset obtained in pressure or flash welding, lies in further pursuing the metal fiber shim brazing technique. Accordingly, a one-year extension of this program is recommended to pursue this approach.

The experimental program would proceed essentially as before with the exceptions that (1) rail steel fiber metal shims will be utilized instead of mild steel fiber metal shims, and (2) the fiber shims would be pre-impregnated with copper. Primary variables to be investigated are:

1. Fiber metal shim density
2. Fiber metal shim thickness
3. Filler metal composition

The feasibility studies during the past year did not include variation of these three primary variables, and, now that feasibility has been shown, these should be studied systematically.

I. CONTRIBUTING PERSONNEL

The work herein reported was performed under the supervision of H. Schwartzbart, supervisor of welding research. Associated with the project were N. Bredzs, research metallurgist, R. K. Nolen, assistant metallurgist, and M. Newman, R. Groell, T. Wonder, and O. Sanders, technicians.

Report on Assignment 2

Laying

E. J. Brown (chairman, subcommittee), H. F. Gilzow, R. A. Hostetter, T. B. Hutcheson, W. J. Jones, H. W. Jenkins, A. B. Lewis, C. R. Merriman, B. M. Monaghan, S. H. Poore, F. L. Rees, C. E. Weller.

This is a progress report, submitted as information.

The total mileage of continuous welded rail as of the end of 1959, by years, is as follows:

Year	*Track Miles*	*Year*	*Track Miles*
1933	0.16	1949	33.05
1934	0.95	1950	50.25
1935	4.06	1951	37.25
1936	1.52	1952	40.00
1937	31.23	1953	80.00
1939	6.04	1954	87.00
1942	5.48	1955	266.50*
1943	6.29	1956	461.43*
1944	12.88	1957	550.12*
1945	4.81	1958	460.24*
1946	3.91	1959	1070.57*
1947	18.70		
1948	29.93	Total	3262.37

* 1955— 72 miles were electric-flash butt welded.
* 1956— 89.10 " " " " " "
* 1957—159.65 " " " " " "
* 1958—312.13 " " " " " "
* 1959—619.92 " " " " " "

The above indicates a decided increase in continuous welded rail mileage since 1955, with a marked increase in 1959. In the latter year, of the mileage shown, 80.58 miles were in yard tracks, the Canadian National Railways having welded 72.08 miles of this total.

Since the last report, one large railroad organized a dual rail laying gang for a 22½-mile rail relay, to accomplish the work in as short a time as possible, in order to get the rail laid and the track surfaced before freezing weather.

The Complement of Men and Equipment in Each Gang of the Dual Organization

1 Foreman, 1 Assistant foreman, 1 General foreman, 1 Timekeeper, 15 Machine operators, 48 Laborers

Kind of Equipment	*Number*	*Machine Operators*	*Laborers*
Ballast rooters	2	2	2
Spike pullers	2	2	2
Adzers	2	2	1
Power track wrenches	2	2	
Line out old rail			1
Remove tie plates			3
Distribute new material			4
Place tie plugs			2
Drive down tie plugs			2
Drive down spike stubs			1
Creosote sprayer	1	1	

Kind of Equipment	*Number*	*Machine Operators*	*Laborers*
Place tie plates			3
Tie plate gage	1		1
Gaging machine	1	1	2
Drive down lock spikes			2
Rubber-tire-mounted crane	1	1	3
Rail laying crane	1	1	3
Spike setters			2
Spike drivers	2	2	2
Pick up old small material			3
Straighten tie plates and bent spikes			2
Setting rail anchors			2
Rail anchor applicator	1	1	
Remove and replace crossing planks			2
Grind adzer bits and other tools			1
Remove old rail anchors			2
	16	15	48

The individual gangs were kept four or five miles apart, so as to avoid any possible delay should one gang be delayed by serious breakdowns in equipment, or other causes. The production of these two units varied with traffic delays, but averaged four quarter-mile strings each eight-hour day.

According to other reports on gang organization received during the past year, the types of organizations vary among the reporting roads, but no radical change from the types described by the committee in previous reports has been made.

Report on Assignment 4

Maintenance

E. P. Hackert (chairman, subcommittee), Frank Aikman, Jr., J. A. Bunjer, C. O. Conatser, R. E. Dove, S. R. Hursh, W. J. Jones, L. W. Leitze, C. P. Martini, Lee Mayfield, F. L. Rees, E. F. Salisbury, R. A. Sharood, R. A. Shaw.

This is a progress report, submitted as information.

In order to gather information for the preparation of a report on methods of maintenance of continuous welded rail, the committee prepared, and submitted to some 30 Class I Railroads, a questionnaire covering various phases of such maintenance. Reference to the recommendations shown in Vol. 54 of the AREA Proceedings was purposely omitted in order to get detailed answers based strictly on such experience as may have been gained in the past five or six years.

Following is a discussion of the items covered in the above-mentioned questionnaire:

1. Derailment Damage—Major

See Table 1.

2. Derailment Damage—Minor (Includes Head and/or Base Gulches, etc.)

See Table 1.

3. Driver Burns

See Table 1.

4. Internal Defects

See Table 1.

5. Replacement of Worn Welded Rail on Curves (75 Ft and over)

From answers received to the questionnaire, it appears that few railroads have had any experience with replacing or transposing curve-worn rail in their continuous welded rail territories. Also, since the replies indicate that very little continuous welded rail is used in curves of over 1 deg 30 min, the information received was not sufficient to evaluate at this time; however, one railroad, the RF&P, reports that in transposing welded rail on curves, the rail is straight-transposed, that is, the low and high rails are interchanged and laid field side to gage. This subject will be pursued further in the carrying out of this assignment at a later date. Two reporting railroads, while not having had any actual experience in transposition or replacement, indicated that any future replacement necessary will be done by using 39-ft rail with 6-hole joint bars.

6. Maintenance of Joints

See Table 1.

7. Inspection of Welds

See Table 1.

8. Maintenance of Gage

Only three railroads reported on this item. Two of these report that the frequency of gaging continuous welded rail, compared with the gaging required for jointed rail, showed little or no difference. In posing this question in the questionnaire, the committee felt that there should possibly be less gaging required of continuous welded rail than of jointed rail. Apparently insufficient experience has been gained by the various roads to furnish this information. This subject will be pursued again at a later date in carrying out this assignment.

9. Pull-Aparts

The probable causes of pull-aparts have been listed variously as: (a) no buffer rail included at insulated joints, (b) rail laid at too high temperatures, (c) improper application of anchors at and near joints, (d) improper maintenance and adjustment of anchors, (e) poor ties at joints, or joints not properly maintained in surface, (f) bolts not inspected annually and replaced where necessary, and (g) insufficient ballast in the cribs and outside the ends of the ties. Of the above probable causes, the most frequently occurring, as determined by answers from the questionnaire, was improper anchorage. Eight of the 14 reporting roads stated this to be the most probable cause of pull-aparts.

For the prevention or correction of pull-aparts, proper attention to the above conditions, it was felt, would assist materially in solving this problem. Again, the application of proper anchor patterns was felt to be the single most important item, along with the installation of a buffer rail at joints where such trouble occurs. In the proper application of anchors as a means of prevention or correction, only one reporting road recommended the use of the AREA recommended anchor pattern per se. Other anchorage patterns recommended varied and are discussed below.

10. Rail Anchors

Information gathered in this regard varied and indicates that at present at least there does not seem to be an accepted standard anchorage pattern. Reporting roads

showed variously 15, 16, 22, 24 and 32 anchors per 39-ft panel, with the 24 per panel predominating, in that 7 of the 14 reporting roads use this number. In the arrangement of anchors, only one road reported using the AREA recommendation; others box each second tie or each third tie, with one road reporting boxing alternate cribs rather than alternate ties. Special anchorage also varied in its application, particularly at insulated joints. Application at these points varied from boxing each tie for 24 ties on both sides of the joint to boxing all ties for as many as 8 rails on both sides of the joint, and various patterns of boxing all ties between these two limits. This varied application applied also to standard joints and switches; there are about as many different applications as there were replies. The committee will pursue this item further at some future time and on a larger scale with a view toward isolating various areas of the country to see what effect the location of the welded rail has on determining anchor patterns.

In the adjustment of rail anchors, the predominance lay in the six-months to one-year bracket, with temperatures between 30 and 50 F.

In the matter of changing the anchor pattern when a repair rail is cut into continuous welded rail, three roads reported no change, and one road each reported boxing each tie for one rail length, boxing each tie for six rail lengths on both sides of the joint, and using the AREA recommended practice.

11. Insulated Joints

The single special maintenance item reported on was that of changing out bolts and insulation in the insulated joints once each year. It was felt, generally, that the practice of changing out bolts, insulation, thimbles and end posts on an annual basis probably did more toward the elimination of trouble at insulated joints than any other single item. To improve maintenance conditions, there were recommended: (a) the installation of two buffer rails instead of one at the joint, (b) shot peening the two center holes at the joint, and (c) the installation of rubber tie pads under all joint plates. Three reporting roads felt that the ultimate answer to insulated-joint maintenance was the design of new and better insulated joints. These recommendations will probably bear some investigation, since the use of the same type of insulated joint in continuous welded rail as is used in ordinary jointed rail may well be the cause of some trouble at these points.

12. Other Maintenance Incidental to CWR

The general consensus regarding non-routine precautions taken in spot surfacing and lining on both tangent track and curves, was to avoid such work in hot weather, to keep the cribs full of ballast while work is being done, and to limit the amount of track being raised at any given time. The maximum temperature at which work is to be done was reported variously from 50 to 90 F, with most of the replies indicating between 75 and 85 F.

Replies were about evenly divided as to whether or not to slow-order track during such spot surfacing and lining operations, with six reporting the practice of slow-ordering and five reporting no slow orders. Those roads which slow order the track do so only during working hours.

For out-of-face surfacing operations, the only non-routine precautions reported were the limiting of the work to periods when the temperature is 75 F or less, or when the temperature is the same as when the rail was laid, or less. During such operations, six roads report applying slow orders to trackage being worked, with four reporting 25 mph slow order during working hours, one keeping slow orders in effect for two days

and one road applying a slow order of 30 mph for the first train. Two roads report that no slow orders are placed.

In the matter of tie renewals with mechanized gangs, three roads limit such operations to the spring or fall, and all of these agree that temperature is a factor, limiting such work to temperatures between 50 and 75 F. In replacing ties with section gangs using hand tools, it is generally reported that no non-routine precautions are taken, and that the renewals are made the same as with ordinary jointed rail.

CONCLUSIONS

Information gathered in this study is so varied in nature, that, with the exception of a few items, no trend toward a standard maintenance procedure is indicated at this time. Generally, in the replacement of rail, either because of derailment damage or because of internal defects found by detector cars, the predominant practice seems to be to replace any such defective continuous welded rail with 39-ft jointed rail, using 6-hole joint bars. The repair of driver-burned rail is being done preferably by gas welding, both preheating and normalizing the rail, with preparation prior to welding done by grinding. The various lengths and depths appearing in Table 1 allowable before repairing driver-burned rail are probably in accordance with the experience of the individual roads, as are the maximum number of repairs allowed per 39-ft rail length.

There is apparently insufficient experience on any of the roads to warrant reporting on the replacement of worn welded rail on curves. This should be an item for investigation at some future date.

In the maintenance of joints, the reports were eight affirmative and five negative as regards lubrication, with the consensus of those which lubricate that the period should be about one year, the same interval applying to the tightening of bolts and the control of torque. In this case there were nine for and four against control of torque, with the interval at which bolts should be tightened again being prodominantly one year.

It was generally felt that the welds should be inspected continually during the life of the rail, either visually, by ultrasonic equipment, or using regular detector cars.

As stated previously, insufficient information was obtained relative to the difference in maintaining gage of continuous welded rail versus jointed rail to warrant discussion at this time.

In the matter of pull-aparts, their probable causes and methods of prevention or correction, the information given above should be helpful since undoubtedly all reporting roads have had at least some, if not considerable, experience with this affliction.

The application of rail anchors and the wide variety of their patterns were somewhat surprising, and while the pursual of this item encroaches somewhat on the assignment of Subcommittee 3, it is felt that application and maintenance are so closely related that the item will be pursued further at a future date and on the basis previously stated.

The matter of insulated joints is discussed above, but your committee would like to recommend the investigation of a possible new and better designed insulated joint as a means of eliminating some of the trouble encountered.

TABLE I

AREA SPECIAL COMMITTEE ON CONTINUOUS WELDED RAIL

METHODS OF MAINTENANCE OF CONTINUOUS WELDED RAIL

	C&O	CRI&P	D&RGW	GN	L&N	MoPac	NYC	N&W	NP	RF&P	SAL	SP	SP&S	UP	AT&SF
Derailment Damage-Major															
Replace with jointed rail		X	X	X		X	X	X	X	X	X	X		X	
4-hole Jt. bars												X			
6-hole Jt. bars		X	X	X		X	X	X	X	X	X			X	
Replace with welded rail															
Gas-shop											X				
Electric-shop												X			X
Derailment Damage-Minor															
Repair in track with joint bars			X				X			X	X	X			
4-hole			X									X			
6-hole				X			X			X	X			X	
Replace- length removed min.			19'-6"					39'		16'	15'	25'			19'6"
Repair rail joined to CWR using															
4-hole bars												X			
6-hole bars		X	X	X	X			X		X	X				X
Driver Burns															
Maximum size repairable			Do not repr.		¼"x3"	¼"x8"	3/8"x10"	3/8"x1"	¼"x6"	1/8"x1⅛"	1/2"x4"	1/2"x6"	1/8"x6"		3/8"x8"
Repaired by gas welding					X	X	X	X	X	X	X	X	X		X
Preheat					No	Yes		Yes	Yes	Yes	No	Yes	Yes		Yes
Normalize					No	Yes	No	No	Yes		No	Yes	Yes		Yes
Prepared by Grinding					X	X	X	X	X	X	X	X	X		X
Acetylene scarfing												X			
Repaired by grinding				X											
Maximum number of repairs per 39' rail						6		4		3	4-6	3			6-8
Internal Defects															
Repaired in track with joint bars			X				X				X				
Removed from track															
39' or over								X						X	
less than 39'							min. 19'6"			Min. 35'	15'				X
Repair rail joined to CWR using															
4-hole bars															
6-hole bars		X	X				X	X		X	X			X	X
Maintenance of joints															
Lubricate	No	yes	Yes			Yes	Yes	No	No	No	No	Yes	yes	Yes	Yes
Interval		1 per yr	1 yr.			6 mo.	At installation					1 yr.	2 yrs.	3 yrs	
Freeze	Yes	No	No				No	No	No	No	Yes	No	No	No	No
Tighten Bolts															
Interval	6 mo.	1 per yr	1 yr.			As needed	1 yr	3-4 yrs	1 yr	3-4 yrs	1 yr	As needed	1 yr	90 days	1 yr
Torque controlled	No	Yes	Yes			No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Inspection of Welds															
For how long after laying should welds be inspected						6 mo.	2 yrs			1 yr	6th & 8th yr then ea. yr	Soon as possible	Life of rail	Life of Rail	Soon as Possible
Interval							Two/week						1 yr		1 yr
Method of inspection:															
Visual	X	X	X				X		X	X daily		X	X		X
Elec. or magnetic		X			X			X			X		X		X
Sonic	X		X							X 2/yr		X		X	X
Radiograph															

Report on Assignment 5

Economics

W. J. Cruse (chairman, subcommittee), Blair Blowers, D. T. Faries, R. J. Gammie, W. L. Jones, T. P. Polson, R. C. Postels, F. L. Rees, Wm. J. Savage, T. C. Shedd, Jr.

This is a progress report, presented as information.

During the past year a review was made of cost data furnished this committee by various railroads in previous years, along with a review of articles appearing in trade magazines concerning costs of welding continuous rail, by both the gas and the electric-flash method. These cost figures vary widely for both methods, and it appears that there is little correlation between the size of the welding program and the cost per weld for the reporting roads.

This committee feels that this wide variation in welding costs is due principally to the varying methods used in compiling cost data. It has planned for 1960 to send the railroads welding continuous rail a questionnaire detailed to include all costs involved in producing continuous welded rail, including the cost of setting up a permanent or temporary welding site, maintenance costs for both fixed plant and special equipment, and dismantling costs if it is a temporary plant. Separate questionnaires will be furnished for the gas and the electric-flash methods.

It is anticipated that these questionnaires will give the committee the necessary information to compile average welding costs on a uniform basis for use by the railroads in determining the economic feasibility of continuous welded rail.

As a matter of information, the following letter received from C. E. R. Haight, chief engineer of the Delaware & Hudson Railroad, states very clearly their stand on the use of continuous welded rail:

"The D&H Railroad has a program for this year (1959) of 10½ miles of 132 RE new rail, and we anticipate continuous welding all of this rail.

"From the experience we have had with continuously welded rail, we feel that the savings not only from the reduction of maintenance costs but, also, from the increased life of the rail without question justify its use.

"The rail which we lay this year will be on curves as well as on tangent track and will be laid in lengths of approximately 1,000 ft. The degree of curvature will not in any way control with regard to the territory where the rail is to be installed; in one particular stretch the curvature is as high as 6 deg."

Report of Committee 5—Track

Troy West, *Chairman,*

S. H. Poore,
Vice Chairman,
A. F. Huber (E), *Secretary,*
J. E. Armstrong, Jr.
J. P. Barker
F. J. Bishop (E)
M. C. Bitner
W. R. Bjorklund
E. G. Brisbin
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M. D. Carothers
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J. T. Collinson
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E. D. Cowlin
F. W. Creedle
P. H. Croft
K. E. Dunn
C. R. Fears
Simon Fogarty, Jr.
H. C. Fox
R. M. Frey
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L. W. Green
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A. E. Haywood
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A. E. Hinson
R. J. Hollinsworth
H. W. Jensen
L. H. Jentoft
C. H. Johnson
A. A. Keever
R. J. D. Kelly
C. N. King
R. E. Kleist
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R. E. Kuston
W. B. Leaf
L. W. Leitze
E. J. Lisy, Jr.
J. E. Martin
C. J. McConaughy
R. E. Misner
W. L. O'Dell
M. P. Oviatt
J. S. Parsons
L. A. Pelton
C. E. Peterson
Ross P. Roden
M. K. Ruppert
J. M. Salmon, Jr.
R. E. Sampson
R. N. Schmidt
V. M. Schwing
R. D. Simpson
T. R. Snodgrass
G. R. Sproles
J. R. Talbott, Jr.
R. E. Tew
K. H. Von Kampen
S. J. Watson
D. J. White
I. V. Wiley
J. B. Wilson
B. J. Worley
M. J. Zeeman
Committee.

(E) Member Emeritus.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Spectrographic testing for analysis in determining the percentage of carbon, phosphorous and copper for steel tie plates and steel track spikes is being considered and will be submitted later as a revision of the present specification.

2. Track tools, collaborating with Purchases and Stores Division, AAR.

   A tee handle drive spike extractor socket wrench has been designed to fit the standard 7/8-in-square drive-spike head. The committee is now working on a design of the stem of the screw spike, and when completed specifications for both the wrench and the spike will be submitted, with drawings, for consideration.

3. Standardization of trackwork plans, collaborating with Signal Section, AAR.

   Progress report, including recommendations with respect to certain plans in the Portfolio of Trackwork Plans submitted for adoption ..... page 935

4. Prevention of damage resulting from brine drippings on track and structures, collaborating with Committee 15, and Mechanical Division, AAR.

   Laboratory work has been continued on evaluating various inhibitors for adding to ice–salt mixtures in refrigerator cars to reduce the corrosive action of brine on track and structure.

5. Design of tie plates, collaborating with Committees 3 and 4.

   Progress report, submitted as information ..... page 945

6. Hold-down fastenings for tie plates, including pads under plates; their effect on tie wear, collaborating with Committee 3.

   Progress report, submitted as information ..... page 948

7. Effect of lubrication in preventing frozen rail joints and retarding corrosion of rail and fastenings.

   Progress report, submitted as information, including recommendations submitted for adoption and publication in the Manual ..... page 953

8. Laying rail tight with frozen joints.

   Progress report, submitted as information ..... page 957

9. Critical review of the subject of speed on curves as affected by present day equipment, collaborating with the AAR Joint Committee on Relation Between Track and Equipment.

   A critical review was made of a proposed formula for the spirals of curves. This formula involves coefficients which will be checked through test and more definitely developed in 1960.

10. Methods of heat treatment, including flame hardening, of bolted rail frogs and split switches, together with methods of repair by welding.

    Progress report, submitted as information ..... page 971

11. Use of rubber or composition plates under insulated joints, collaborating with Signal Section, AAR.

    This subject is being currently studied under Assignment 5.

12. Develop a standard plan for a drive screw spike with a ⅞-in-square head.

    This subject is being carried out under Assignment 2.

THE COMMITTEE ON TRACK,

TROY WEST, *Chairman.*

Report on Assignment 3

Standardization of Trackwork Plans

Collaborating with Signal Section, AAR

M. J. Zeeman (chairman, subcommittee), J. E. Armstrong, Jr., J. P. Barker, M. C. Bitner, W. R. Bjorklund, R. J. Bruce, E. W. Caruthers, J. T. Collinson, W. E. Cornell, F. W. Creedle, K. E. Dunn, C. R. Fears, H. C. Fox, R. M. Frey, J. W. Fulmer, M. J. Hassan, A. E. Haywood, R. J. Hollingsworth, A. F. Huber, H. W. Jensen, C. H. Johnson, R. J. D. Kelly, C. N. King, T. R. Klingel, R. E. Kuston, L. W. Leitze, E. J. Lisy, Jr., C. J. McConaughy, R. E. Misner, W. L. O'Dell, J. S. Parsons, C. E. Peterson, S. H. Poore, R. N. Schmidt, R. D. Simpson, T. R. Snodgrass, G. R. Sproles, K. H. Von Kampen, S. J. Watson, Troy West, I. V. Wiley, J. B. Wilson, B. J. Worley.

Your committee submits for approval as recommended practice and publication in the Manual (Portfolio of Trackwork Plans) Plan No. 980–60, Turnout and Crossover Data for Tongue Switch Construction for Use in Pavement, and the withdrawal of the previous issue of this plan, No. 980–54.

Besides a change in the title and in the Notes, this plan has been completely revised. Data for diesel operation have been added. Tabulated information for turnouts and crossovers is shown, and data for Nos. 4, 7 and 9 turnouts have been added. The alinement of the turnouts has been changed so that the point of tangent of the lead curve coincides with the toe ends of tee rail frogs rather than with the toe ends of girder rail frogs.

Your committee also recommends for approval as recommended practice and publication in the Trackwork Portfolio Plan Nos. 982–60, 987–60, 988–60 and 989–60, with revisions in titles and notes, and the withdrawal of the previous issue of these plans, namely, Plan Nos. 982–55, 987–55, 988–55 and 989–55. The proposed revisions are as follows (the revised plans are not presented herein):

Plan No. 982–60, Revision of Plan No. 982–55

Change title to read as follows:

200′ RADIUS TONGUE SWITCH AND MATE
FOR LOCOMOTIVE DRIVING TRUCK
WITH TWO PAIRS OF FLANGED WHEELS
(Diesel or Steam Locomotives)
SOLID MANGANESE STEEL
FOR USE IN PAVEMENT

Change Note 1 to read as follows:

1. This plan shows R.H. 200′ radius tongue switch and mate suitable for industrial tracks or locations not subject to through traffic and for operation of diesel or steam locomotives with two pairs of flanged wheels on driving truck.

Add new Note 2 reading as follows:

2. REFERENCES: See Plan Basic No. 980 for:
   - A. Turnout alinements suitable for this plan.
   - B. Reference to switch plan for double tongue switches for locomotive with two pairs of flanged wheels.
   - C. Reference to switch plans designed for locomotives with other wheel mountings.

Renumber present Notes 2 and 7, incl., as 3 to 8, incl.

Plan No. 987–60, Revision of Plan No. 987–55

Change title to read as follows:

STRAIGHT DOUBLE TONGUE SWITCHES
FOR LOCOMOTIVE DRIVING TRUCK
WITH TWO PAIRS OF FLANGED WHEELS
(Diesel or Steam Locomotives)
SOLID MANGANESE STEEL
FOR USE IN PAVEMENT

Change Note 1 to read as follows:

1. This plan shows double tongue switches for operation of diesel or steam locomotives with two pairs of flanged wheels on driving truck.

(No change in Note 2.)

Change Note 3 to read as follows:

3. REFERENCES: See Plan Basic No. 980 for:
   A. Turnout alinements suitable for this plan.
   B. Reference to switch plan for curved tongue switch and mate for locomotive with two pairs of flanged wheels.
   C. Reference to switch plans designed for locomotive with other wheel mountings.

Eliminate present Note 4.

Renumber present Notes 5 to 10, incl., as 4 to 9, incl.

Plan No. 988–60, Revision of Plan No. 988–55

Change title to read as follows:

STRAIGHT DOUBLE TONGUE SWITCHES
FOR LOCOMOTIVE DRIVING TRUCK
WITH THREE PAIRS OF FLANGED WHEELS
(Diesel or Steam Locomotive—See NOTE 1)
SOLID MANGANESE STEEL
FOR USE IN PAVEMENT

Change Note 1 to read as follows:

1. This plan shows double tongue switches for operation of locomotives with three pairs of flanged wheels on driving truck; wheel base not exceeding 15′–7″ for diesel locomotives or 13′–0″ for steam locomotives.

(No change in Note 2.)

Change Note 3 to read as follows:

3. REFERENCES: See Plan Basic No. 980 for:
   A. Turnout alinements suitable for this plan.
   B. Reference to switch plans designed for locomotives with other wheel mountings.

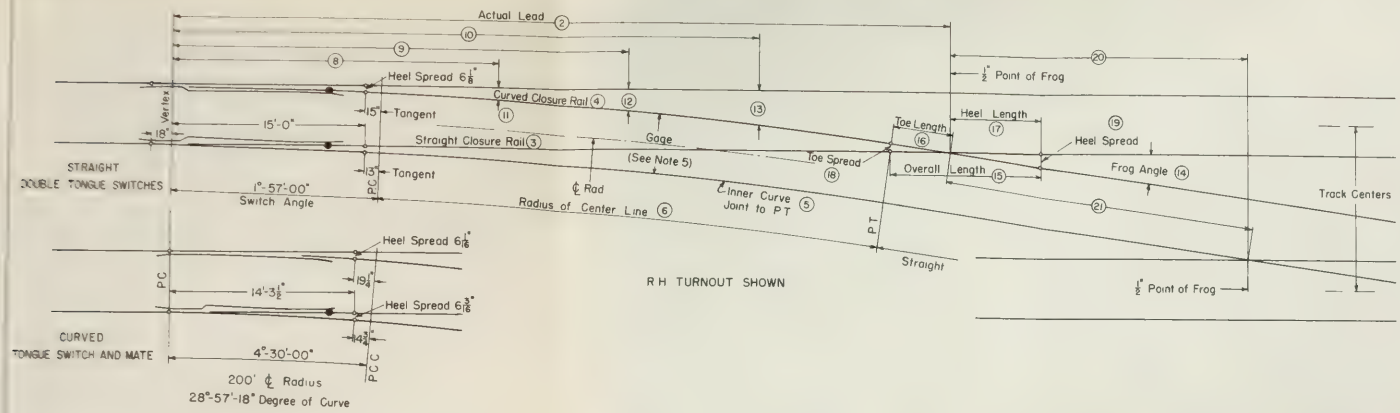
Eliminate Note 4.

Renumber present Notes 5 to 10, incl., as 4 to 9, incl.

Plan No. 989–60, Revision of Plan No. 989–55

Change title to read as follows:

DOUBLE
TONGUE S
Straight
Curved



TURNOUT AND CROSSOVER DATA

Type Switch	Col. (1)	Col (2)	Closure Distance Col (3)	Closure Distance Col (4)	Closure Distance Col (5)	Lead Curve Col. (6)	Lead Curve Col (7)	Gage Line Offsets Col (8)	Gage Line Offsets Col (9)	Gage Line Offsets Col (10)	Gage Line Offsets Col (11)	Gage Line Offsets Col (12)	Gage Line Offsets Col (13)	Properties of Frogs Col (1)	Properties of Frogs Col. (14)	Properties of Frogs Col. (15)	Properties of Frogs Col. (16)	Properties of Frogs Col. (17)	Properties of Frogs Col. (18)	Properties of Frogs Col. (19)	Data for Crossovers 13'-0" Track Centers Col. (20)	Data for Crossovers 13'-0" Track Centers Col. (21)	Data for Crossovers For change of 1'-0" in Track Centers	Data for Crossovers For change of 1'-0" in Track Centers
	Frog Number	Actual Lead	Straight Closure Rail (See NOTE 6)	Curved Closure Rail (See NOTE 6)	Inner Curve (Joint to PT)	Radius of Center Line	Degree of Curve							Frog Number	Frog Angle	Overall Length	Toe Length	Heel Length	Toe Spread	Heel Spread	Straight Track	Crossover Track	Straight Track	Crossover Track
		Ft In	Ft In	Ft In	Ft In	Feet	Deg.Min.Sec.	Ft In	Ft In	Ft In	Inches	Inches Ft In	Ft In		Deg.Min.Sec.	Ft. In.	Ft In	Ft In.	Inches	Inches	Ft In	Ft In	Ft In	Ft In.
Straight Double Tongue Switches (alignment - above sketch)	4	43-2	24-10	25-2 3/4	24-0 3/8	109.47	54-21-21	21-2	27-4	33-6	9 15/16	17 15/16	2-5 7/8	4	14-15-00	8-0	3-4	4-8	9 7/16	14 3/8	13-2 1/4	14-9 3/4	3-11 1/4	4-0 3/4
	5	49-6	30-11 1/2	31-3 1/4	30-4	179.45	32-21-24	22-9	30-6	38-3	10 7/16	19 7/16	2-7 3/8	5	11-25-16	9-0	3-6 1/2	5-5 1/2	7 15/16	13 9/16	16-10 5/16	18-1 7/8	4-11 7/8	5-0 5/8
	6	55-6	36-9	37-0 1/4	36-2 3/8	268 28	21-28-57	24-2	33-4	42-6	11 1/4	20 5/8	2-8 3/4	6	9-31-38	10-0	3-9	6-3	7	13	20-5 1/2	21-6 1/2	5-11 1/2	6-0 1/2
	7	60-9	41-0 1/2	41-3 1/4	40-7 1/4	366 15	15-41-50	25-3	35-6	45-9	11 3/8	20 9/16	2-8 13/16	7	8-10-16	12-0	4-8 1/2	7-3 1/2	7 9/16	13	24-0 3/8	24-11 5/8	6-11 3/16	7-0 7/16
	8	66-1	46-0	46-2 1/2	45-7 3/8	492.42	11-39-21	26-6	38-0	49-6	12 1/8	21 7/16	2-9 15/16	8	7-09-10	13-0	5-1	7-11	7 5/8	12 3/8	27-7 5/8	28-4 5/8	7-11 3/8	8-0 3/8
	9	70-8	49-3 1/2	49-5 3/4	48-11 1/2	623 81	9-11-41	27-4	39-8	52-0	12 3/8	21 1/2	2-9 3/4	9	6-21-35	16-0	6-4 1/2	9-7 1/2	8	13 5/16	31-1 5/8	31-10 3/8	8-11 11/16	9-0 5/16
	10	75-8	54-3	54-5	53-11 3/8	804 51	7-07-35	28-7	42-2	55-9	12 13/16	22 1/4	2-10 7/16	10	5-43-29	16-6	6-5	10-1	7 3/16	12 5/8	34-8 5/8	35-3 1/8	9-11 5/16	10-0 5/16
Curved Tongue Switch and Mate (alignment - above sketch)	4	39-2	21-6 1/2	21-11 1/2	20-9 1/8	117 02	50-35-19	19-8	25-0	30-4	11 13/16	20 3/8	2-7 7/8	4	14-15-00	8-0	3-4	4-8	9 7/16	14 3/8	13-2 1/4	14-9 3/4	3-11 1/4	4-0 3/4
	5	43-10	26-0	26-4 1/8	25-4 1/2	202 44	28-35-54	20-9	27-3	33-9	12 15/16	22 1/16	2-9 5/8	5	11-25-16	9-0	3-6 1/2	5-5 1/2	7 13/16	13 9/16	16-10 5/16	18-1 5/8	4-11 5/8	5-0 3/8
	6	48-1	30-0 1/2	30-4	29-6 1/2	324.93	17-42-13	21-9	29-3	36-9	13 1/16	23 7/16	2-11 3/8	6	9-31-38	10-0	3-9	6-3	7	13	20-5 1/2	21-6 1/2	5-11 1/2	6-0 1/2
	7	51-8	32-8	32-11 1/8	32-3	486 64	11-47-40	22-5	30-7	38-9	14 3/8	2-0 1/16	2-11 5/8	7	8-10-16	12-0	4-8 1/2	7-3 1/2	7 9/16	13	24-0 3/8	24-11 5/8	6-11 3/16	7-0 7/16
	8	55-2	35-9 1/2	36-0 1/4	35-5 1/4	740 92	7-44-20	23-3	32-2	41-1	14 7/8	2-1 5/16	3-0 1/2	8	7-09-10	13-0	5-1	7-11	7 5/8	12 3/8	27-7 5/8	28-4 5/8	7-11 3/8	8-0 3/8
	9	58-2	37-6	37-8 3/8	37-2 1/4	1111.17	5-09-29	23-8	33-0	42-4	15 3/8	2-1 1/4	3-0 1/4	9	6-21-35	16-0	6-4 1/2	9-7 1/2	8	13 5/16	31-1 5/8	31-10 3/8	8-11 5/8	9-0 3/8
	10	61-3	40-6 1/2	40-9	40-3 1/4	1827.90	3-08-06	24-5	34-6	44-7	15 13/16	2-2 1/4	3-1 5/16	10	5-43-29	16-6	6-5	10-1	7 3/16	12 5/8	34-8 5/8	35-3 1/8	9-11 5/16	10-0 5/16

NOTES

1. For details of STRAIGHT DOUBLE TONGUE SWITCHES for operation of diesel or steam locomotives with two pairs of flanged wheels on driving truck, see Plan Basic No. 987.
2. For details of STRAIGHT DOUBLE TONGUE SWITCHES for operation of locomotives with three pairs of flanged wheels on driving truck; wheel base not exceeding 13'-7" for diesel locomotives or 13'-10" for steam locomotives, see Plan Basic No. 988.
3. For details of STRAIGHT DOUBLE TONGUE SWITCHES for operation of steam locomotives with three or more pairs of flanged wheels on driving truck; wheel base over 13'-0", but not exceeding 19'-0", see Plan Basic No. 989.
4. For details of 200' RADIUS TONGUE SWITCH AND MATE suitable for industrial tracks or locations not subject to through traffic and for operation of diesel or steam locomotives with two pairs of flanged wheels on driving truck, see Plan Basic No. 982.
5. GAGE—The data shown are computed for turnouts out of straight standard 4'-8½" gage track. For turnouts using STRAIGHT DOUBLE TONGUE SWITCHES for operation of locomotives with three or more pairs of flanged wheels on driving truck, the gage shall be widened in accordance with Plan Basic No. 791 at the midway point of the curved closure rail. The widening shall be done by moving the inside curved rail out and tapering the gage to standard 4'-8½" at the heel of the switch and toe of the frog.
6. FROG DESIGNS—For turnouts using solid manganese steel frogs the straight and outside curved closures shall be lengthened to conform.

American Railway Engineering Association

Construction and Maintenance Section
Association of American Railroads

TURNOUT AND CROSSOVER DATA FOR TONGUE SWITCH CONSTRUCTION FOR USE IN PAVEMENT

PLAN NO. 980-60

STRAIGHT DOUBLE TONGUE SWITCHES FOR LOCOMOTIVE DRIVING TRUCK WITH THREE OR MORE PAIRS OF FLANGED WHEELS (Steam Locomotives—See NOTE 1) SOLID MANGANESE STEEL FOR USE IN PAVEMENT

Change Note 1 to read as follows:

1. This plan shows double tongue switches for operation of steam locomotives with three or more pairs of flanged wheels on driving truck; wheel base over 13′–0″, but not exceeding 19′–0″.

(No change in No. 2.)

Change Note 3 to read as follows:

3. REFERENCES: See Plan Basic No. 980 for:
   A. Turnout alinements suitable for this plan.
   B. Reference to switch plans designed for locomotives with other wheel mountings.

Eliminate Note 4.

Renumber present Notes 5 to 10, incl., as 4 to 9, incl.

Your committee submits, as information, a report prepared by the research staff of the Engineering Division, AAR, included herein as Appendix 3–a, Service Tests of Designs of Manganese Steel Castings in Crossings at McCook, Ill.

Assignment 3 now reads "Standardization of Trackwork Plans, collaborating with Signal Section, AAR." The Trackwork Portfolio contains plans of a variety of trackwork material, but this year your committee concentrated its efforts on submitting to you our recommendations for standard turnouts with their component parts. Due to the various numbers of turnouts as well as types of construction now used by the railroads, it is not expected that we can please every railroad. Our recommendations are based mainly on the best possible combinations of frogs, switches and guard rails into a few selected turnouts which could be made standard for general use, taking into consideration the extent of present use as well as economy.

Experience gained from previous efforts to standardize on a few turnouts indicated that a small group of members, serving as a procedure or steering committee, could make some recommendations on this subject so that the deliberations of the subcommittee would follow an orderly fashion. Accordingly, a special committee of five members of the subcommittee was appointed, with T. R. Klingel as chairman and M. C. Bitner, F. W. Creedle, A. E. Haywood and L. W. Leitze as members.

This special committee rendered a report, dated September 9, 1959, which, at a subsequent subcommittee meeting, was thoroughly discussed and then approved with only a few minor editorial changes. After this, at a meeting of the Track committee, the report of the subcommittee was approved.

Because the report of Mr. Klingel's committee contains considerable information as to the reasons why certain turnouts and their parts have been selected as proposed standards, we think it should be made available to the AREA membership. For this reason, your committee submits, as information, Appendix 3–b, Report of the Special Committee of Subcommittee 3, Committee 5—Track, on Standardization of Turnouts.

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Your committee submits the following recommendations for standard turnouts, as information, looking to submitting these recommendations in the form of plans to the 1961 convention for adoption and publication in the Trackwork Portfolio.

1. Turnouts for main track, through-train movements:

Turnout No.	*Switch*	*Designation*
20	39′ curved	High speed
15	26′ curved	Medium speed
10	16′ 6″ straight	Low speed

2. Turnouts for yard and switch movements:

Turnout No.	*Switch*	*Recommended use*
8	16′ 6″ straight	For movement at slow speeds. In heavy-duty locations, No. 10 main-track turnout may be used.
6	11′ straight	Where limited space prevents using No. 8 turnout.

3. All switches to have graduated risers with level heels.
4. All curved switch points to be planed per detail 5100 (undercut stock rail) on Plan No. 221–55. All straight switch points planed per detail 4000 (¼″ point chamfered to $\frac{1}{16}$″). Fully bolted heel joints per detail 1125.
5. Horizontal rods and adjustable side jaw clips, per Plan No. 222–51, to be used with all switches.
6. Adjustable rail braces with type A fit, per Plan No. 224–55, to be used for all main-track switches.
7. Change the 60′ 0″ stock rails called for on Plan No. 921–52 for 26′ and 39′ curved switch to 39′ 0″ stock rails.
8. Revise Plan No. 128–55 where necessary as called for in items 4, 5, 6 and 7 above for 39′ curved switches.
9. Revise Plan No. 126–55 where necessary as called for in items 4, 5, 6 and 7 above for 26′ curved switches.
10. Revise Plan No. 112–55, 16′ 6″ straight switch, per items 4 and 5, above. Adjustable braces to be used for main-track switches and rigid braces to be used for yard switches. Except for the braces, the switch is to be identical.
11. 11′ straight switch with rigid braces, per Plan No. 114–55, other details similar to the 16′ 6″ yard switch.
12. Railbound manganese-steel frogs for Nos. 10, 15 and 20 main track and Nos. 6 and 8 yard turnouts, per Plan No. 621–55. This plan to be revised, reducing wall thickness at locations where this can be done without affecting service life of frog, also to make this design applicable for all rail sections.
13. Besides the No. 10 railbound manganese steel frog, included in item 12, above, we recommend adoption of a No. 10 spring rail frog for main-track turnouts, per Plan No. 401–55, long spring rail design, with same toe and heel lengths as the railbound manganese frog.

14. Besides the Nos. 6 and 8 railbound manganese steel frogs included in item 12, above, we recommend adoption of a No. 6 and No. 8 solid manganese self-guarded frog for yard turnouts, per Plan No. 641–55.
15. Manganese-steel one-piece guard rails for heavy-duty main-track turnouts, per Plan No. 510–40 and tee rail guard rails, per Plan No. 504–55, for other locations.

The committee feels that there is a definite need for complete turnout plans for the five turnouts recommended as standard, one plan for each turnout number. This plan would be complete, including switch, frog, guard rails, turnout data, typical rail layout, ties and their spacing, etc. Such a plan would eliminate the necessity of consulting a great number of plans in order to get data for a complete turnout, required under the present system. Then each turnout plan would be followed by a detail plan of the switch, frog and guard rails. If the above basic recommendations for the five turnouts meet with general approval, it means that about 20 new plans are required and, of course, the revision of a great number of other plans now in the Portfolio. We propose to place these five turnout plans with the supporting detail plans, suitably designated as standard plans and recommended practice, in the front of the Portfolio, and to place all other remaining plans in the back of the Portfolio, as information.

It is quite obvious that the program outlined above involves a lot of work and considerable expense. We believe that the committee could not be expected to go ahead with this program unless there is some expression from the AREA membership that the recommended standards are generally satisfactory. If the green light is received at the convention, we will proceed as quickly as possible, hoping to submit the actual plans for your approval as recommended practice at the 1961 convention.

The committee expresses its appreciation to its associate members, the manufacturers, for their valuable assistance.

Appendix 3–a

Service Tests of Designs of Manganese-Steel Castings in Crossings at McCook, Ill.

This report, presented as information, covers the service test of the last remaining test casting in the double-track lines of the Baltimore & Ohio Chicago Terminal Railroad and the Atchison, Topeka & Santa Fe Railway at McCook, Ill.

During the 12-month period, ended August 1959, the total length of the flangeway cracks in the Ramapo deepened flangeway casting increased from 26 to 32 lin in, including only 6 in. in the fillets. The short sidewall crack on the Santa Fe receiving corner was the same except there was an offset of 1/8 in. in the wall. This crack extended into the tread and was not discernible in the wheel path. Otherwise, the casting was in a good state of repair in that no grinding or welding was needed. In recent years the two receiving corners have been periodically recapped by welding.

On September 29, 1959, after 6.98 years of service and approximately 370 million gross tons of traffic, the deepened flangeway casting was retired. The condition of the Santa Fe receiving corner having the combined running surface and sidewall cracks was the deciding factor. This casting as well as the two U. S. Steel solid pedestal type castings were supported throughout the service tests with longitudinally framed timbers having two 8- by 10-in timbers bolted together for each rail. The Santa Fe tracks were supported by the continuous timbers and the B&OCT had the continuous bearing plates.

The two U. S. S. solid pedestal castings were placed in service in the diamond carrying eastward traffic on both lines, October 1952. The plain, unhardened U. S. S. casting was retired after 3.60 years of traffic amounting to 234 million gross tons. The depth-hardened U. S. S. steel casting was removed from service June 3, 1957, after 4.44 years service and 290 million gross tons of traffic.

All tonnage estimates are based on the check made of the 1952 tonnage of the two railroads.

The shot-peened depth-hardened casting of the original Morden–Ramapo design was removed from service March 5, 1956, after 6.8 years of traffic amounting to 440 million gross tons. This casting was moved to a second location at approximately the midpoint of its service life and was favored by having the receiving corner impacts from both lines well distributed over the three tread corners.

Summary

A report on the physical characteristics and the stress measurements made with the two designs of castings was published in the Proceedings, Vol. 55, 1954, page 1. The two U. S. S. solid pedestal castings showed that the depth-hardened frog was in service 0.8 year longer and carried 56 million more gross tons of traffic than the unhardened casting. In addition, both the depth-hardened castings were in service 26 months before the first welding of the battered tread corners, as compared with 18 months for the U. S. S. unhardened casting. The greater service life of the Ramapo deepened-flangeway design than that of the U. .S S. solid pedestal type castings, indicates some advantage for the more flexible casting. The U. S. S. casting with rigid support of the tread corners, also developed the higher receiving corner flangeway fillet stresses. This investigation was started in 1943 when some of the castings of prevailing designs had as little as 18 months of service.

All of the test castings were those used in the end position with a height of 6¼ in to match 110 RE rail and an intersection angle of 75 deg 48 min.

Acknowledgement

The Association acknowledges its deep appreciation to the B&OCT for its cooperation and assistance in making this 16-year investigation possible. Cooperation on the part of the Santa Fe Railway in extending the test period with the lighter weight castings and in other ways is gratefully acknowledged. The Association is also greatly indebted to the following suppliers who have cooperated in the conduct of these tests by furnishing castings of new designs and in many other ways: Railroad Products Division, American Brake Shoe Company; Johnstown Works of United States Steel Corporation; Trackwork Division, Taylor–Wharton Iron & Steel Company (Weir–Kilby); Bethlehem Steel Company; Morden Frog and Crossing Works (now American Brake Shoe Company); Manganese Track Society, and the American Wheelabrator & Equipment Company (shot peening).

Appendix 3–b

Report of the Special Committee of Subcommittee 3, Committee 5—Track, on Standardization of Turnouts

This special committee was appointed by M. J. Zeeman, chairman, Subcommittee 3, at the meeting of May 18, 1959, to study the various plans of frogs, switches and turnouts, with their numerous alternates, in the Portfolio of Trackwork Plans and to

submit recommendations to the subcommittee at the meeting of September 15, 1959, on a limited number of turnouts to be designated as Standard Turnouts in the Portfolio.

The committee concluded that some expense would be incurred by any railroad changing over to a new standard and that the advantages to be gained in adopting any standard would have to exceed these costs if the standard were to be adopted generally. Reduction in inventory of track material by the use of fewer designs of turnouts can be accomplished by any railroad within its own organization at the present time without resorting to an industry-wide standardization program and, therefore, cannot be claimed as an advantage to be gained by industry-wide standardization. Reduction in manufacturing costs by mass production of fewer designs is the prime factor in securing universal adoption of uniform standards throughout the country.

The questionnaire submitted to all chief engineers in 1956 to determine the extent of use of the present Trackwork Plans was reviewed to determine what information was available for use in the present study to select recommended turnouts. It was concluded that very little of the information obtained by this questionnaire would be of value in this study. No definite pattern could be established regarding the turnouts used at the present time or which of the numerous alternates offered by the plans at the present time were used predominantly. Membership on the Track committee at present represents about one-third of the Class I Railroad Companies, about 72 percent of the mileage of Class I Railroads and the major manufacturers of trackwork. It is the opinion of this committee that the decisions of the Track committee on standardization would be as representative of the thinking of the railroad industry as a questionnaire to the chief engineers of the Class I Railroads.

In selecting turnouts for main-line use, it was decided that a high-speed, a medium-speed and a low-speed turnout would be adequate, and that these speeds should conform in general to the three speed ranges of normal signal operation in use in this country at the present time. Following is a tabulation of turnouts recommended for main line use:

Turnouts for Through-Train Movements

Turnout No.	*Switch*	*Max Speed (MPH)* *Lateral*	*Equilateral*	*Designation*
20	39′ curved	50	70	High speed
15	26′ curved	38	53	Medium speed
10	16′ 6″ straight	20	28	Low speed

Allowable speed is the prime factor that dictates the use of a high-speed or a medium-speed turnout. Curved switches allow a higher speed than a straight switch, give a smoother ride and are easier to maintain at high speeds. They are, therefore, recommended for the No. 20 and the No. 15 turnouts, the high-speed and the medium-speed turnouts, respectively. Speed through the No. 10 turnout, the low-speed turnout, is not as important a factor, and the difference in speed between the curved switch and the straight switch for this turnout is relatively minor. In the interests of economy, the straight switch is recommended for the No. 10 turnout.

The No. 20 turnout is the longest turnout recommended by AREA and included in the Portfolio, and has accordingly been selected as the high-speed turnout. The No. 10 turnout is the only turnout which the questionnaire indicated is used extensively by a majority of roads at the present time for low-speed through-train movements. This turnout is satisfactory for a low-speed turnout. The allowable speed conforms to accepted signal indications for low speeds, and with a straight switch it is economical to install

and maintain and has, therefore, been selected as the low-speed turnout. The No. 15 turnout with a curved switch allows train speeds with an adequate factor of safety for current accepted medium-speed signal indications for a diverging route. It is a logical intermediate turnout between the high-speed and the low-speed turnouts, and the questionnaire indicated that it is used more extensively at the present time than either the next higher or next lower turnout number. It provides a suitable turnout for the many locations where light traffic density and slower speeds do not justify the expense of a No. 20 turnout but where the low speed of a No. 10 turnout is objectionable. The No. 15 turnout with a 26′ curved switch is, therefore, recommended as a medium-speed turnout.

The committee is of the opinion that two turnouts are required for yard and switch movements—one for normal use and one for locations where a sharper turnout is required because of limited space or rigid alinement requirements. The following tabulation lists the turnouts recommended for this use:

Turnouts for Yard and Switch Movements

Turnout No.	*Switch*	*Speed (MPH)*	*Recommended Use*
8	.....16′ 6″ straight	19	To be used for yard and switch movements at slow speeds. Where frequent train movements are made, the No. 10 turnout recommended for low-speed through-train movements may be used.
6	.....11′ straight	13	To be used only where limited space or rigid alinement requirements make the use of a No. 8 turnout impossible or impractical.

The No. 8 turnout is an economical turnout for yard and switch movements and is used extensively at the present time. The curvature, which was considered by some roads as objectionable for steam locomotive operation, is no longer a problem with diesel locomotives. Sharper turnouts would be harder to maintain and longer turnouts would reduce track capacity unnecessarily. The No. 8 turnout is recommended as an economical turnout suitable as a standard turnout for yard and switch movements. There are numerous locations in congested areas where limited space or rigid alinement requirements make the use of a sharper turnout necessary or desirable. For these locations the No. 6 turnout is recommended.

Turnouts other than those recommended above that are required for special situations should be relatively rare and should be considered as "special trackwork." The benefits and economies to be realized by standardization would not acrue to these turnouts.

It is recommended that standard switches for all of the above turnouts have graduated risers instead of uniform rivers. Following are the advantages and disadvantages of graduated risers which were considered in arriving at this conclusion:

1. The cost of a complete switch with graduated risers is less than that of switch with uniform risers because of level heel fillers and hook twin tie plates.
2. Heel blocks are of the same hand for graduated risers, thereby reducing the number of castings which must be carried in stock.
3. The elevation runoff in lead rails is shorter for graduated risers than for uniform risers, but the difference is considered minor.

4. The hook twin tie plates used with graduated risers allow more tolerance in the positioning of switch ties, but do not position the rails as rigidly as the one piece plates with milled rail seats used with uniform risers.
5. Switch points with vertical bends for graduated risers cost slightly more than switch points for uniform risers, but the over-all cost for the complete switch is less with graduated risers.

Plan No. 128–55 is the plan of a 39′ 0″ curved switch with graduated risers, which is recommended for a No. 20 turnout. The following alternates shown on this plan or on Plan Basic Nos. 127, 221, 222, 223, 224, 920 and 921, to which this plan makes reference, are recommended as standard, and any reference to any other alternates or designs is to be deleted from the plan to provide a plan for a recommended standard switch.

Plan No. 127: Information on stock rail planing and bending and on tie spacing is to be shown on the proposed standard plan.

Plan No. 221: Detail No. 5100 with the undercut stock rail is recommended for the curved switch point, and Detail No. 4000 with the ¼″ point is recommended for the straight switch point. Longer service life and reduced maintenance are secured by the use of the undercut stock rail and by the use of the ¼″ switch point and they are, therefore, recommended as standard. Detail No. 6100 should be deleted from the standard plan. The fully bolted heel joint assembly with a shoulder bolt is recommended as standard, and reference to the floating heel assembly with a thimble should be deleted from the standard. A stronger heel joint assembly and reduced maintenance of switch point clearance are obtained by the use of the rigid heel assembly. Improved rail anchorage of recent years has largely eliminated former objections to the rigid heel joint assembly.

Plan No. 222: The adjustable side jaw clip is recommended as the standard clip for fastening the switch points to the switch rods. This clip has the advantage of the adjustment of the transit clip and retains the advantages of the side jaw clip. The switch rods are simpler and cheaper than for the transit clips. All details and reference to other clips are to be removed from the standard plan. Information on the switch rod with basket adjustment is to be retained for interlocked switches. It appears that the adjustable side jaw clip will interfere with the operating rod from the basket, and this question will have to be resolved on the standard plan.

Plan No. 223: This plan on switch plates and rigid rail braces contains no alternates and is satisfactory as at present.

Plan No. 224: The type "A" adjustable rail brace is considered by the committee as preferable and is recommended as standard. Reference to type "B" braces is to be deleted from the standard plan.

Plan No. 920: The standard plan should contain alinement data for the No. 20 turnout with a 39′ curved switch and the No. 15 turnout with a 26′ curved switch with point detail Nos. 4000 and 5100 only.

Plan No. 921: This plan designates length of stock rails and closure rails for Type L and Type S turnouts. The length of stock rails for both the 39′ and the 26′ curved switches is 60′. The committee recommends that the subcommittee review the question of length of stock rails before adopting a standard since the high cost of 60′ rails from the mills and the advent of welded rail may have changed some of the factors that originally led to the adoption of these 60′ stock rails.

The bill of material on Plan No. 128 must be revised so as to conform with the above recommendations.

Plan No. 126–55 is the plan of a 26′ curved switch with graduated risers recommended for a No. 15 turnout. Information shown on plan No. 125 on stock rail planing and bending and on switch tie spacing must be shown on the standard plan. Details of manufacturer and alternates referred to on Plan Nos. 221, 222, 223, 224, 920 and 921 are to be the same as recommended for the 39′ curved switch for the No. 20 turnout. The bill of material on plan No. 126 must be revised so as to conform with the above recommendations.

Plan No. 112–55 is the plan of a 16′ 6″ straight switch with graduated risers recommended for a No. 10 turnout. The committee believes the use of adjustable rail braces is desirable for all main-line turnouts. Reference to the use of rigid rail braces on hand-throw switches and adjustable rail braces on interlocked switches is to be deleted and adjustable rail braces shown for all No. 10 turnouts.

Plan No. 221: The ¼″ point per Detail 4000 is recommended. All other alternates on this plan are to be the same as for the 39′ and the 26′ curved switches.

Plan Nos. 222, 223 and 224: Details and alternates on these plans should be the same as recommended for the 39′ and the 26′ curved switches.

Plan Nos. 920 and 921: The standard plan should show only the information from these two plans that applies to the recommended turnouts.

The bill of material on Plan No. 112 must be revised so as to conform with the above recommendations.

Plan No. 112–55 is the plan of a 16′ 6″ straight switch with graduated risers recommended for use with a No. 8 turnout. This switch is to be identical with the 16′ 6″ switch recommended for the No. 10 turnout with the exception that rigid rail braces are recommended instead of the adjustable rail braces, since this switch is recommended for yard and switch movements. The bill of material shown on Plan No. 112 will have to be revised so as to conform with these recommendations.

Plan No. 114–55 is the plan of an 11′ 0″ straight switch with graduated risers recommended for use with a No. 6 turnout. This switch is to have ¼″ points per Detail 4000, rigid rail braces and other details and alternates as recommended for the 16′ 6″ straight switch for a No. 8 turnout. The bill of material shown on plan No. 114 will have to be revised so as to conform with these recommendations.

Rail-bound manganese frogs are recommended as standard for all of the turnouts recommended as standard. Plan No. 600 is of a thin-wall manganese casting and plan No. 621 is of a heavy-wall manganese casting for 112-lb rail and heavier. There are a number of disadvantages to the thin-wall design, so the committee recommends as standard Plan No. 621, Rail-Bound Manganese Frogs of Heavy-Wall Design, modified to accommodate all standard rail sections and further study by the subcommittee to determine whether it would not be possible to reduce the thickness of walls at locations which would not affect the service life of the frog.

Plan No. 401 is the plan of a No. 10 spring rail frog with a long spring rail. This frog is recommended as a standard for No. 10 turnouts. The long spring rail design is preferred since it is interchangeable with the No. 10 rail-bound manganese frog.

Plan No. 641 is a plan of a solid manganese self-guarded frog. It is recommended this frog be a standard for No. 6 and No. 8 turnouts for yard and switch service. The committee did not have time to consider the alternates shown on this plan and, therefore, makes no recommendations regarding these alternates other than that the plan adopted as standard should contain no alternates.

Plan No. 504 is the plan of a guard rail of tee rail design, and Plan No. 510 is the plan of a guard rail of one-piece manganese-steel design. The committee recommends

as standard the use of one piece manganese steel guard rails for turnouts in main lines carrying high-density high-speed traffic, and the use of tee rail design guard rails in all other locations.

This special committee was appointed as a steering committee to make recommendations to Subcommittee 3 on standard turnouts so that the meditations and discussions of the subcommittee could follow an orderly pattern. This report is intended to serve that purpose. No detailed cross-check of all of the plans and specifications that may be affected by these recommendations has been made by the committee, and the plans referred to in this report cannot, therefore, be assumed to be the only plans that would be affected by, or would have to be revised, so as to conform with these recommendations.

The committee is indebted to Al Huber who, at our invitation, joined us at our meetings and gave us the benefit of his extensive knowledge and years of experience in this field.

T. R. Klingel, *Chairman,*
Chief Engineer
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M. C. Bitner
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Chief Engineer
Railroad Products Division
American Brake Shoe Company

A. E. Haywood
Assistant Engineer Maintenance of Way
Grand Trunk Western Railroad

L. W. Leitze
Engineer of Track
Great Northern Railway

Report on Assignment 5

Design of Tie Plates

Collaborating with Committees 3 and 4

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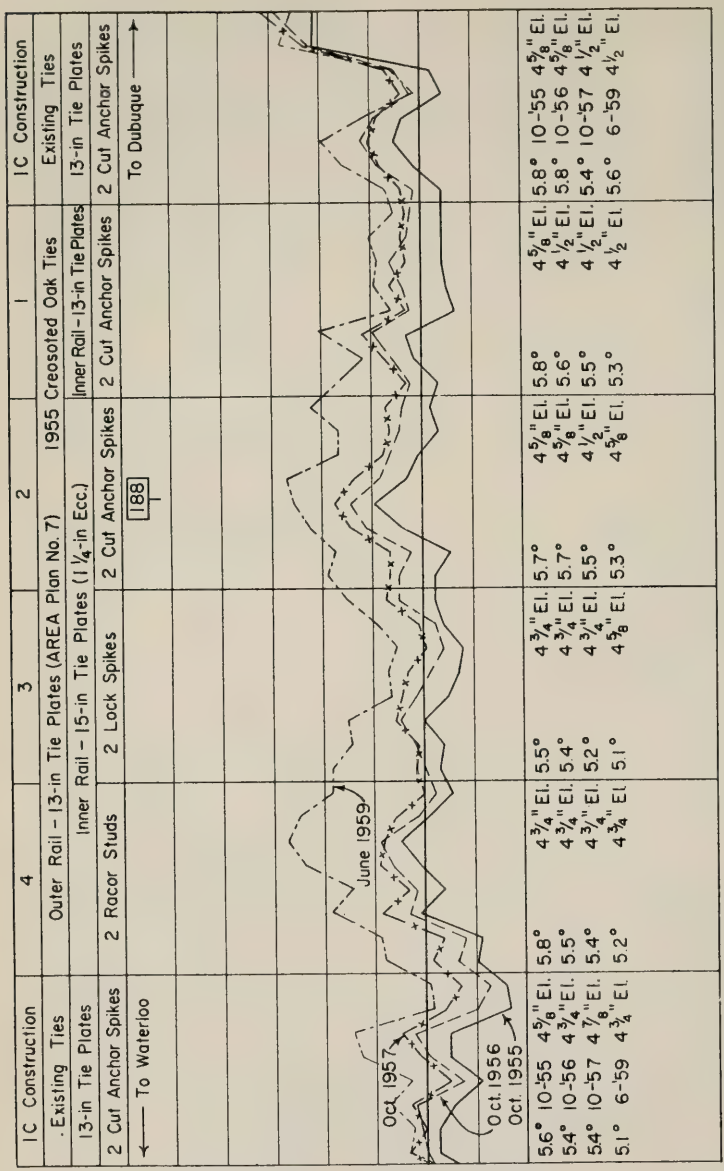
This report, presented as information, covers the service test of the special 8-in by 15-in by 1-in thick tie plates with 1¼-in eccentricity on a 6-deg curve on the Iowa Division of the Illinois Central Railroad near Dubuque, Iowa.

The field investigation and preparation of this report are under the general direction of G. M. Magee, director of engineering research, AAR. H. E. Durham, research engineer track, is in direct charge, assisted by members of his staff.

Introduction

The special plates, similar to AREA Plan No. 20 with the exception of the 1-in uniform thickness, milled rail seats, and bars welded in place for the shoulders, were reinstalled on the 6-deg curve in the single-track main, August 1955. The construction consists of four test sections of two track panels each, with twenty-four 7-in by 9-in by 8-ft 6-in sawed creosoted oak ties per panel, as outlined in the report on this subject in the Proceedings, Vol. 57, 1956, page 706. The last three sections (Fig. 1) have the



Note: All test sections have 2 cut line spikes. Each section includes 2 panels of track. The curve was relaid in November 1954 with new 115 RE rail and 6-hole headfree joint bars. The joints in sections with new 1955 ties are supported with 3 ties. The IC construction has special rail braces, fastened with 3 screw spikes and placed against the field side of both rails on every 4th tie. The rail braces were omitted from the sections with the 1955 ties.

Fig. 1. Gage, Curvature and Elevation of Each Test Section on 6-deg Curve at IC Mile Post W-188, Iowa Division.

TABLE 1. SERVICE TEST OF MECHANICAL WEAR OF TIES WITH TWO DESIGNS OF TIE PLATES AND THREE TYPES OF HOLD-DOWN FASTENINGS FOR 115 RE RAIL ON CREOSOTED OAK TIES IN THE 6° CURVE OF THE ILLINOIS CENTRAL RAILROAD MILE POST W-188, NEAR DUBUQUE, IOWA

Service Period - October 1955 to June 1959

Section	Hold-Down Fastenings	Length of Tie Plate in	Tie Plate Penetration in 0.001 in							Percent of Controls
			Inner Rail			Outer Rail			Avg Both Rails	
			Field End	Gage End	Avg	Gage End	Field End	Avg		
1	2 cut anchor spikes	13	57	54	55				62	100
	2 cut anchor spikes	13				53	86	70		
2	2 cut anchor spikes	15	38	55	46				61	98
	2 cut anchor spikes	13				58	97	77		
3	2 lock spikes	15	10	17	13				23	37
	2 lock spikes	13				25	44	34		
4	2 Racor studs	15	23	22	22				45	73
	2 Racor studs	13				52	86	69		

Note: All test sections have two cut line spikes. Each section includes two panels of track. The curve was relaid in November 1954 with new 115 RE rail and six-hole headfree joint bars. The 8 x 15 x 1-in thick plates have 1 1/4-in eccentricity. The 13-in tie plates have eight-hole punching per AREA Plan No. 7

15-in plates on the inner rail and 13-in AREA Plan No. 7 plates on the outer rail. Section 1 used for controls has 13-in plates under both rails. Sections 1 and 2 have two cut spikes for anchors, section 3 two lock spikes, and section 4 two Racor studs for anchors.

Initial readings of tie abrasion, gage of track, elevation and curvature of each panel were taken in October 1955. Measurements were recorded in 1956 and repeated in 1957. Two members of the AAR staff took the latest measurements in June 1959. During the 3.7-year service period, the test panels have carried 50.3 million gross tons of traffic, of which 29.4 million were eastbound.

Tie Plate Penetration

Table 1 is a summary of the tie wear data for the 3.7-year service period. This is the first data released on the penetration because of the relatively small amount of wear heretofore.

The 15-in tie plates with 1¼-in eccentricity have, to date, reasonably well equalized the plate cutting on the low (inner) rail, but this is also true of the 13-in plates in section No. 1. It will be noted that the penetration of the 13-in plates under the outer rail is substantially greater than that of the 15-in plates under the inner rail.

At the time the test was established it was contemplated that westward freight trains on an ascending grade would operate below thte equilibrium speed of 34 mph. The changeover from steam to diesel operation has apparently resulted in speeds somewhat greater up hill, thus creating more plate cutting of the ties under the outer rail.

It is rather early in the tests to make comparisons of the different types of installations, but from an examination of Table 1 it is readily apparent that those plates with

lock spikes are showing the least tie abrasion. The studs appear to be doing well where used in the 15-in plates on the inner rail, but show no advantage over cut spikes on the outer rail. Nine of the 192 lock spikes in section No. 3 were found to be loose, 8 of which were on the outer rail. This compares with 70 loose Racor studs in section No. 4, of which 67 are on the outer rail.

Gage of Track

Fig. 1 indicates the changes in the gage of track, curvature and elevation during the test cycles.

Widening of the gage in the existing tie sections, which precede and follow the test sections, has been held to a minimum by the presence of special rail braces on every fourth tie held in place against the field side of the rail with three screw spikes. In these two sections the widening has averaged 0.13 in during the 3.7-year period.

In sections 1 and 2 with 1955 ties and cut spike construction, the gage widening for the same period was 0.17 in and 0.25 in, respectively, as compared to 0.19 in for the lock spike section and 0.26 in for the Racor stud section. During the last two-year service period, only sections 2 and 4 have shown an appreciable amount of gage widening. Wear of the outer rail accounted for 0.08 in of the gage widening since the test was established.

The cross level and curvature have held reasonably constant during the life of the test.

Discussion

During this relatively short test period, it is apparent that pressure on the outer rail is much greater than anticipated. To obtain the desired results, consideration will be given to reversing the plates between the two rails to place the special plates in the outer rail. It is too expensive to provide additional shop-made plates.

Acknowledgement

The Association is indebted to the Illinois Central for its cooperation in this investigation and extends its thanks to the suppliers for their assistance.

Report on Assignment 6

Hold-Down Fastenings for Tie Plates, Including Pads Under Plates; Their Effect on Tie Wear

Collaborating with Committee 3

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This report of progress, submitted as information, includes the results of an inspection of the test installations of tie pads and hold-down fastenings, etc., on the Louisvillle & Nashville Railroad and progress made with the AAR design of tie wear machines in the Engineering Laboratory at the Research Center.

TEST ON THE LOUISVILLE & NASHVILLE RAILROAD

Introduction

Since August 1947, service tests have been conducted with tie pads, coatings, sealing compounds and several designs of hold-down fastenings in the northward main track of the L&N near London, Ky. The test track is laid with 131 RE rail and carries approximately 15 million gross tons of traffic per year, consisting largely of loaded coal cars. Additions and/or changes in the test sections have been made each year, with few exceptions.

The objective of these tests is to determine the most effective and economical methods of extending the service life of ties by reducing plate cutting and the frequency of readzing and regaging curves.

Because of the retrenchment in the funds appropriated for the Research Center, the work on this service test was confined to (1) assisting the committee make an annual inspection on May 27, 1959, (2) checking test sections 35 and 36 having the Koppers' No. 16 tie sealing compound, and (3) supervising the alteration of two test sections and taking the base readings. The AAR detailed inspection and measurement of gage of the curves were omitted. No maintenance work was performed on the fastenings.

The test was last reported in the Proceedings, Vol. 60, 1959, page 800, which included tables and location plans describing the test sections.

Revisions to Test Sections in 1959

Section 28

Forty-eight tire carcass pads, $\frac{3}{16}$ in thick and coated on both sides, manufactured by the Konvex Tie Pad Company of East St. Louis, Ill., were installed October 10, 1959, in the north one-half of section 28 on the long 4½-deg curve south of East Bernstadt, replacing the Western Felt Works wool felt pads. The 1958 Konvex pads had a sheet of brown wrapping paper on the top of the pad (convex side) to prevent the seal with the tie plate. Because the plates in the 1959 inspection were sealed to the pads, a polyethylene film about 0.01 in thick was placed on top of the 1959 pads. In addition, the stabilized rubber coating was modified to increase its resistance to the elements and retain its adhesive qualities. The Konvex pads were placed on 24 new creosoted oak ties using new 14-in double-shoulder tie plates and two cut spikes each for line and anchor. The south one-half of section 28 was replaced with Konvex pads and new ties, August 1958 (see Vol. 60, page 801).

Section 56

On October 10, 1959, 68 Fabco pads with a new type of coating on the underside were installed on the 5-deg curve at East Bernstadt. The 34 pads on the north one-half of the section are ¼ in thick, and the remaining 34 on the south end are ⅛ in thick. These pads replaced Fabco pads of similar thicknesses which were installed in June 1955 on new ties. The same ties and 14-in double-shoulder plates were used with two cut spikes each for line and anchor for the new installation. The coating referred to as "Super-Seal" has an improved formulation of asphalt applied over a rubber-based primer coat on the bottom side only. The 1959 coating is ⅛ in thick, or $\frac{1}{16}$ in thicker than on the 1955 pads, giving the pads an over-all thickness of ¼ in and ⅜ in for the ⅛-in and ¼-in uncoated pads, respectively.

Initial readings were taken after the traffic had settled the plates on the pads.

Annual Inspection

The subcommittee made its inspection on May 27, 1959. Forty-seven committee members and guests observed most of the test installations while removing 15 tie plates for a detailed inspection of tie pads, special fastenings, the condition of the tie under the tie plate, etc. Members of the AAR and L&N staffs escorted the party over the installations. The L&N and some of the suppliers furnished auto transportation. Photographs were taken of the conditions found. Because of a shower in the afternoon before the following morning inspection, free water was found under some of the tie pads removed for inspection. The more significant and informative observations are listed as follows: All curves have creosoted oak ties.

1. Section 40, tie 32, 14-in Bird 5-ply LD (Jute) pad coated on both sides, three years of service, inner rail 5-deg curve. The pad had a good seal and was in good condition.
2. Section 46, tie 40, 14-in Racor fiber-rubber pad coated on both sides, 7.5 years of service, inner rail 5-deg curve. The pad was in good condition, but was not sealed. The wood was damp under the pad and some sand was observed.
3. Section 47, tie 22, 14-in Burkart (1952) fiber pad bottom coated, 6.9 years of service, inner rail 5-deg curve. Some abrasion was noted on the top of tie pad but it was in reasonably good condition. The pad was not sealed and the wood under it was wet.
4. Section 55, tie 16, 14-in Johns–Manville fiber-rubber pad, ¼ in thick, bottom coated, 3.9 years of service, inner rail 5-deg curve. The pad was not sealed, but was in good condition. The wood under the pad was wet with some sand.
5. Section 56, tie 15, 14-in Fabco fiber-rubber tie pads, ¼ in thick, bottom coated, 3.9 years of service, inner rail 5-deg curve. This pad was not sealed and had sand under it. Wood under the pad was damp. The pad condition was good. The asphaltic coating adhered to the tie on ¾ of the pad area. Previous inspections indicated the 1955 Fabco pads had maintained a seal for almost three years. No ⅛-in-thick, bottom-coated Fabco pads in the south half of this section were removed at this inspection. The above sections, 55 and 56, are on the south spiral of the curve which reduces the severity of the test below that of the body of the curve. All of the Fabco pads in section 56 were replaced with the same thickness pads having an improved coating, October 1959. The 1955 pads removed were examined, and there was evidence that a few of the ⅛-in-thick pads had worn thin around the anchor spikes at the field end. Possibly the ⅛-in thickness is inadequate for the service conditions.
6. Section 28, tie 28, $\frac{3}{16}$-in-thick Konvex tire carcass tie pads 14 in long, coated on both sides, 0.8 year of service, outer rail long 4½-deg curve. The pad was sealed to the tie and the tie plate. The brown wrapping paper placed on top of the pad did not prevent sealing to the tie plate. However, the bond with the wood was stronger than with the tie plate. The wood under the pad was dry.
7. Section 4, tie 41, 13-in Bird 5-ply duck-burlap tie pad coated on both sides, 10.8 years of service, outer rail long 4½-deg curve. Pad was sealed on ½ the area and was in good condition. The underplate area had some sand on it but there was no free water.
8. Section 5, tie 5, 13-in Bird 7-ply duck-burlap tie pad coated on both sides, 10.8 years of service, outer rail long 4½-deg curve. One-half of the pad was

sealed to the tie and the other half had free water under it and some sand. There was some abrasion and compression of the wood at the field end of the plate where there was no seal. Pad was in moderately good condition.

9. Section 5, tie 29, 13-in Bird 7-ply duck-felt pad coated on both sides, 11.8 years of service, outer rail long 4½-deg curve. This pad was delaminated, but ¾ of its area was sealed. The sealed area was dry.
10. Section 48, tie 30, 14-in Racor pad coated on both sides and two Racor studs as anchor spikes, 6.8 years of service, outer rail long 4½-deg curve. The pad had ⅞ the area sealed on the wood, which was clean and dry.
11. Section 58, tie 21, 7- by 9¼-in Railroad Rubber Products, Inc., double-shoulder canted rubber tie plate, four cut line spikes on creosoted oak ties, 0.8 year of service, west rail tangent track. The tie had no plate cutting but there was a slight compression of the springwood. Some of the tie plate holes had splits caused by driving the spikes. The 39-ft panel of rubber tie plates had good line and surface.

The following pads were removed from creosoted pine ties in tangent track to show the difference in protection provided by sealed and unsealed tie pads.

12. Section 5, tie 12, 13-in Bird 7-ply duck-felt pad coated on both sides, 11.8 years service in the west rail. This pad was not sealed and the underplate area was wet. The pad condition was reasonably good.
13. Section 21, tie 23, 13-in Fabco pad, ¼ in thick, uncoated, 11.8 years service in the west rail. The pad condition was fair and the wood was wet under the tie plate. It was estimated in the field that the average depth of tie abrasion and compression under the Fabco pad was three times as large as that under the Bird 7-ply duck-felt pad which may have retained a seal with the tie over one-half of its service life.

Tie Coatings

As reported last year, the north 30 odd-numbered ties in Section 35 were recoated in August 1958, using Koppers' No. 16 tie sealing compound spread over the top surface only, and covered by ¼-in stone chips. It was decided that recoating part of this section would develop more information on the subject than if all coated ties were recoated. Section 35 as well as Section 36 were started in July 1950 with the same aforementioned sealing compound on the tops and ends of new and existing creosoted hardwood ties to determine if the sealant could retard splitting, checking and weathering of the ties. The coating was applied to all adzed surfaces of the 120 ties and on top of the odd-numbered ties in Section 35, leaving the even-numbered ties for controls. The ends of the coated ties in the south half of this section were also coated. Section 36 had an application on the tops of all of the 118 existing ties and also the ends of the south 58 ties. All of the coated ties were sprinkled with ¼-in washed gravel for a protective covering. The weather at the time of the annual inspection on May 26, 1959, was rainy with a temperature about 75 F. Because of the presence of free water on the ties no correct moisture readings could be taken with the meter.

The efficiency index of the coating for keeping the splits covered was determined from the number of splits ⅛ in wide or larger on the top end faces of the ties. The efficiency factors for the new ties in Section 35 were obtained from the following formula:

$$\text{Efficiency, percent} = 100 - \left(\frac{\text{number of checks in coated ties}}{\text{number of checks in uncoated ties}}\right) \times 100$$

Because all of the existing ties were coated in Section 36, the original number of splits in the ties before being coated was used for computing the efficiency factors.

Values for the coverage efficiency of the coating for the nine-year test are tabulated as follows:

	Section 35—1950 Ties					
	Percent					
Category	*1951*	*1953*	*1955*	*1957*	*1958*	*1959*
All coated ties	75	76	52	58	39	72
Ties coated on top only*	70	73	45	53	36	89
Ties coated on top and ends	79	80	60	63	42	53

* Ties were recoated after the 1958 readings.

	Section 36—Existing Ties					
	Percent					
Category	*1951*	*1953*	*1955*	*1957*	*1958*	*1959*
All coated ties	82	70	55	48	44	55
Ties coated on top only	64	61	44	43	38	47
Ties coated on top and ends	97	79	66	54	51	62

It will be noted that the values have increased in all categories of both sections. This occurrence may have been influenced by having more rainfall in the spring of 1959 than for 1958.

The ties in Section 35, which were recoated after the data were taken in 1958, have shown a marked increase in efficiency. These ties were coated on the top only. Several of the major splits in the 1950 ties could not be completely filled with the compound. The recoated ties had an increase in coverage efficiency from 36 to 89 percent, which in turn raised the over-all efficiency factor in this section from 39 percent to 72 percent. The first tie renewals since the start of the test were recorded in Section 35 during the last service period. The three renewed were 1950 coated ties in the south half of the section.

Twelve ties were renewed in Section 36 during this service period. Altogether 16 ties in Section 36 with 118 ties have been renewed prior to May 1959. As a matter of interest, the cause of replacing the three 1950 ties was splitting.

After renewal of 20 to 30 percent of the 1950 ties in Section 35, the life of the coated and uncoated ties can be estimated.

Laboratory Tests with the Tie-Wear Machines

During 1959, the first AAR design of tie-wear machine was operated 23 million test cycles in 20 separate tests, including several short tests of tie pads on the concrete tie. Seven tests were conducted on creosoted oak ties for controls, one new type of hold-down fastening and three kinds of tie pads, including one new formulation which was rejected for use in track. Altogether approximately 11 million cycles were involved in the tests on wood ties. The earlier tests with the alternating lateral forces of 10,000 lb outward and 5,000 lb inward of the rail, and 20,000 lb vertical tie plate loads indicated that the lateral forces were too large for the vertical load and caused breakage of the ⅝- by 6-in cut spikes in the anchor position. The first change in the machine was to increase its speed from 128 to 173 cpm to shorten the unloaded interval of time and thus have less time for abrading the wood, etc. This change did not reduce the severity of the test sufficiently, and Machine No. 1 was modified to reduce the horizontal forces to 7,500 lb outward and 3,750 inward of the rail and keep the vertical load the same. After this change was completed in July 1959, the machine was used to conduct 13 miscel-

laneous tests with the concrete tie, and for proving new designs of clips, insulating bushings and selecting suitable tie pads for use under the 5- by 14-in tie plate design to be used on concrete ties in track. Several formulations of rubber pads and fiber-rubber pads were given short tests, but all were unsatisfactory in permitting too much lateral movement of the tie plate with respect to the concrete tie, when loaded with 2¾ through bolts, each having 10,000 lb tension. These materials had inadequate yield strength and too much deformation resulting from the shear stress. Tests with 3/16-in and ¼-in-thick plastic pads and with ½-in marine plywood shims, reduced the lateral movement of the tie plate to an average of less than 0.010 in.

The second tie-wear machine of the AAR design was built during the year as a duplicate of the modified machine in order to increase the capacity for testing pads and fastenings. The control test with a 7¾- by 14-in tie plate, four cut spikes and a short piece of creosoted oak tie were completed at the end of 1960. The results of the test so far indicate the machine will be satisfactory for the evaluation of tie pads, hold-down fastenings, etc.

General Remarks

In previous reports two types of ⅛-in-thick pads were found failing and will not give a good service life under the test conditions. Reference is made to the Dunne Rubber Company's molded rubber pads in the 5-deg curve and the ⅛-in-thick J-M laminated rubber-asbestos pads in the short 4½-deg curve. There was an indication that the Fabco ⅛-in-thick pads in the 5-deg curve may be too thin for the test conditions. Last year's report listed the tie pads that were not satisfactory for the service conditions.

Acknowledgement

The Association is indebted to the L&N for its cooperation and assistance in making this investigation, and also extends thanks to the suppliers who have rendered assistance in several ways.

Report on Assignment 7

Effect of Lubrication in Preventing Frozen Rail Joints and Retarding Corrosion of Rail and Fastenings

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This progress report consists of two parts: Part 1 presents changes in recommended practice for preserving rail joints, based on extensive service tests, submitted for adoption and publication in the Manual. Part 2 describes service tests of rail joint preservation on the Richmond, Fredericksburg & Potomac and the protection of rail and fastenings from corrosion in the Seattle tunnel on the Great Northern and in brine territory on the Chicago & North Western.

This field investigation is being conducted by the AAR research staff under the general direction of G. M. Magee, director of engineering research, with H. E. Durham, research engineer track, in direct charge, assisted by members of his staff.

PART 1. PROPOSED REVISIONS OF THE MANUAL

Your committee submits the following recommendations with respect to Manual material on oiling track fixtures. During the last 14 years more information on preserv-

ing joints has been developed, and it is desired to bring up to date references pertaining to rail joint preservation. The investigation for protecting rail and fastenings from brine corrosion has been initiated.

Page 5–5–9

OILING TRACK FIXTURES

Delete, substituting the following:

PRESERVATION OF TRACK FIXTURES

The following is recommended as good practice:

1. Rail Joints

a. When assembling rail joints in territory where corrosion is moderate, the rail ends should be protected from corrosion by the application of a brush coat of metal preservative. In territory where corrosion is severe, the bars should also be coated, and end plugs can be used to preserve the bolts. All bolts should be coated with a grease-type preservative when applied. Field end hardening of the rail should be done prior to applying rust preventives to the joints.

Petrolatum or petrolatum-based compounds with a corrosion inhibitor, will give good protection in the joints.

b. In track where damaging corrosion exists or the joints have become frozen, the spray method of preserving the joints without removing the bars is recommended at suitable intervals. Application to the inside and outside of the joints can be made economically with suitable spray equipment.

Petrolatum, asphalt, and petroleum oil-based compounds, preferably containing a wetting agent and a corrosion inhibitor, can be used to control corrosion and prevent or eliminate frozen joints, broken bolts and stripped joints. Best results can be obtained if applied during warm weather.

2. Rail and Other Track Material, Except Joints

a. Oil turnout fixtures, except on surfaces where graphite is used.

b. Oil rail, tie plates and spikes when subjected to special corrosive conditions where ultimate life is affected.

c. Oiling of rail, tie plates and spikes can be done by a spray machine.

d. Satisfactory oil for this purpose should conform to the following general specifications:

Asphalt Base Dipping Oil Specifications

Flash point, min	130 deg F
Asphalt, 100 penetration, min	45 percent
Viscosity, Saybolt Universal, 130 deg F	240–350 sec

Pages 5–5–1 to 5–5–3, incl.

SPECIFICATIONS FOR LAYING RAIL

On page 5–5–2, delete the first paragraph under Sec. C, substituting the following:

As the rail is laid, all joints shall be given a brush coat of a metal preservative in accordance with Art. 1a of Preservation of Track Fixtures, Part 5, this Chapter.

PART 2. SERVICE TESTS

Tests on the RF&P

Foreword

In January 1957, the RF&P installed 140 RE rail with six-hole headfree bars to replace 131 RE rail on a 2-deg curve in the northward main track (No. 1) at MP 100, near Franconia, Va. Prior to laying the rail the chief engineer of the railroad kindly offered to incorporate some of the suggestions of the AAR research staff to provide protection to the joints. The track is subject to heavy brine drip, and it was agreed to have receiving end plugs in all joints to prevent failure of the end bolts from corrosion. Three methods of joint preservation were each successively applied to every third joint in each rail to have comparable brine drip for the three variations of corrosion protection around the curve. Sixty-six joints each had (1) RMC plastic joint packing packed solid except for 3 in at the rail ends left for drainage and ventilation, (2) brush coat of Conoco Anti-Rust Compound with Texaco Plastic "H" receiving end plugs, and (3) receiving end plugs made of approximately a 6-in length of RMC plastic packing with no other preservative.

As a supplementary test, the RF&P applied Texaco 904 graphite grease to nine joints, Texaco 1978 (Rust Proof LB) to nine joints and No-Ox-Id "GG" to two joints immediately north of the AAR-RF&P test. Both Texaco 1978 and Conoco Anti-Rust compound were petrolatum based with a solvent and a corrosion inhibitor. The former preservative also contained carbon black.

The inner rail (east) with even joint numbers was laid on the first day, which was cold and wet. All materials were heated, but it was impossible to obtain a good brush coat on the rail ends. Some of the compounds were applied with a paddle which explains the reason for finding a heavy coat, particularly in the case of Texaco 904 grease. It was cold on the second day but dry, and the application of the rust preventives to the rail was much better than on the first day. Joints laid in the outer rail the second day have odd numbers. The relative performance of the compounds can be evaluated best from the conditions observed in the odd-numbered joints.

Annual gross tonnage carried by the track is approximately 25 million, consisting of both freight and passenger trains. Maximum speeds are 80 mph for passenger trains and 50 mph for freight trains.

Inspection

On August 5, 1959, 13 members and guests of the Track committee were escorted over the test track by members of the RF&P and AAR staffs during the dismantling and inspecting of nine joints, with findings as follows:

1. Joints No. 20, east (inner) rail and No. 79, west (outer) rail with RMC Plastic packing solid except 3 in at the rail ends: The bolts in both joints were in good condition. There was slight corrosion at the receiving ends of the bars for a short distance, but for the remainder of the length, protection was good on the bars and rail. Joint No. 20 had no bleeding at the bearing surfaces, but these surfaces of Joint No. 79 were well covered. The packing of No. 79 was partly missing at the receiving end.
2. Joints No. 22, east (inner) rail, and No. 75, west (outer) rail, with brush coat of Conoco Anti-Rust Compound and Texaco Plastic "H" receiving end plugs: The bolts were in good condition and the bearing surfaces generally well covered. Joint No. 75 had slight corrosion at the receiving end of the gage bar,

whereas No. 22 had corrosion on top of the rail base for about 6 in from the receiving end of the bars and 2-in from the leaving end. There was also a small amount of corrosion on the web of the rail and bars.

3. Joints No. 42, east (inner) rail, and No. 119, west (outer) rail, with 6-in RMC Plastic packing plugs in receiving end of joint with no other lubrication: The receiving end bolts of these two joints were fairly well protected; however, many of the plugs in other joints were all or partially gone. Joint No. 42 had no serious corrosion, but there was considerable rust under the bars on No. 119 on the outer rail.
4. Joint No. 201 with Texaco 904 was well coated on bars and rail without corrosion, and the bolts were well protected. This joint had a heavy coat of grease on the rail web.
5. Joint No. 215 with Texaco 1978 had a good coating on the bars and rail except for 3 in on the upper receiving end. The bolts were in good condition.
6. Joint No. 219 with No-Ox-Id "GG" has corrosion for about 6 in at the receiving end of the bars, also under the head at the end of the receiving rail. The cover was poor on the bearing surfaces.

Discussion

After 2.5 years of service, the AAR-RF&P test shows favorable results with the RMC Plastic packing applied solid except at the rail ends and with brush coat of Conoco Anti-Rust compound and receiving end plugs of Texaco Plastic "H". The bolts were well protected, and the only corrosion of moment was observed at the receiving end of the bars.

The 6-in RMC Plastic end plugs in the receiving ends of the joints were effective only to the extent that the plugs in place were protecting the end bolts. However, many of the plugs had vibrated out. The material had poor retention as an end plug.

In the RF&P supplemental tests, the Texaco 904 and 1978 material provided generally good protection. No-Ox-Id "GG" was not showing up favorably. Joint 219 with a brush coat of No-Ox-Id "GG" had less coverage on the fishings, but the rail web was protected.

The present service period is not sufficient to completely evaluate the applications.

Great Northern Railway Tests

Tunnel Corrosion

The application of preservative coatings to rail in the tunnel at Seattle, Wash., affected by conditions of continual high humidity and unsatisfactory ventilation, was reported in the Proceedings, Vol. 60, 1959, page 797.

A total of 107 rails were coated with four proprietary compositions. A neoprene-base coating, which had shown merit in previous tests, was applied to the bulk of the rails. A few rails were coated with an asphalt-derived material containing flaked aluminum, an asphaltic mastic applied over a wash primer, and a coal-tar pipeline coating.

Examination of the coated rails one year after initiation of the test showed that the neoprene-base coating was still in excellent condition. The asphaltic mastic has disintegrated slightly but still was affording good protection. In the wetter locations in the tunnel, rails coated with the remaining materials had begun to show the formation of rusted areas, and these coatings have, in general, deteriorated more rapidly than the others.

Periodic inspections of the specimens will continue, and the results will be made available to the committee.

Proposed Test on Chicago & North Western Railway

For the purpose of service testing the efficiency and economy of several types of metal preservatives in retarding brine corrosion, a location has been selected on the eastbound track of the C&NW just west of Low Moor, Iowa, approximately 145 miles from Chicago.

It is proposed to establish one track mile each of No-Ox-Id 100, Texaco 45, RCX-236 and Texaco 55 with full coating applied to the exposed surfaces of rail, tie plates and other fastenings, including joint bars. An effort was made to apply the material during the fall of 1959, but difficulties were encountered in heating the metal preservatives to obtain good atomization with the nozzles and spray equipment available. The application will be completed in 1960 when weather conditions are favorable and suitable equipment is available.

Acknowledgement

The Association is indebted to the RF&P, the GN and the C&NW for their cooperation and assistance in the conduct of these projects, and extends its appreciation to the cooperating suppliers for their aid and interest in this corrosion problem.

Report on Assignment 8

Laying Rail Tight with Frozen Joints

J. B. Wilson (chairman, subcommittee), J. P. Barker, F. J. Bishop, M. C. Bitner, H. B. Christianson, P. H. Croft, C. R. Fears, Simon Fogarty, Jr., J. W. Fulmer, L. W. Green, A. B. Hillman, A. B. Hillman, Jr., L. H. Jentoft, A. A. Keever, R. J. D. Kelly, C. N. King, R. E. Kleist, W. B. Leaf, L. W. Leitze, J. E. Martin, R. E. Misner, M. P. Oviatt, S. H. Poore, R. P. Roden, J. M. Salmon, Jr., R. N. Schmidt, V. M. Schwing, G. R. Sproles, J. R. Talbott, Jr., Troy West, D. J. White.

This is a progress report on the service tests of tight rail compared to rail laid with normal bolt tension and expansion on the Louisville & Nashville Railroad, the Erie Railroad, and the Bessemer & Lake Erie Railroad. The tight rail on the L&N is not end hardened while that on the Erie is end hardened and beveled. The B&LE rail is end hardened and beveled in the north one-half mile and plain end without beveling in the south one-half mile. The bolt tension is 35,000 lb for 1-in bolts on the Erie and 45,000 lb for 1⅛-in bolts on the L&N and B&LE.

This report also includes laboratory tests of glued joints carried out at the AAR Research Center.

The field investigation and laboratory tests were carried out under the general supervision of G. M. Magee, director of engineering research. H. E. Durham, research engineer track, with his staff, has direct charge of the assignment.

TEST ON LOUISVILLE & NASHVILLE RAILROAD

Introduction

The Louisville & Nashville laid a tangent section containing approximately one mile of tight rail near Chapel Hill, Tenn., in November 1953 using 132 RE rail with 6-hole headfree joint bars, 1⅛-in track bolts and 45,000 lb average tension on the bolts. The rail ends were end milled without beveling or end hardening. The anchorage is as described in Fig. 1. For a complete description of the test, see the Proceedings, Vol. 57, 1956, page 704.

Since the AAR test was established in October 1955, there have been approximately 55 million gross tons of traffic, with northward tonnage being slightly greater than southward. The total gross tonnage since laying the tight rail in November 1953 was approximately 77 million.

On August 25, 1959, three members of the subcommittee, together with an AAR representative, and six others walked over the test area and made a general inspection. On the following day members of the AAR staff measured joint gaps and rail creepage and recorded rail end chipping. As bolt tightening in the tight rail section was not contemplated for another year, loss of bolt tension was not measured. Rail surface profiles were not checked.

Rail Joint Gaps and Cumulative Rail Creepage

Winter rail gaps and creepage of the rails were recorded by the L&N staff on February 20, 1959, with an average rail temperature of 20 deg (Figs. 1 and 2). Summer gaps and rail creepage recorded by the AAR staff on August 26, 1959, with average rail temperatures of 129 deg and 123 deg for the normal rail and tight rail, respectively, are shown in Figs. 3 and 4.

The winter tight rail gaps (Fig. 2) averaged 0.006 in for 211 joints at 20 deg on February 20, 1959, compared with an average of 0.001 in at 12 deg on January 8, 1958. The number of open joints decreased from 16 to 12, but the average gap of open joints increased from 0.014 in to 0.108 in. The gaps of the normal rail remained practically constant, averaging 0.170 in at 12 deg on January 8, 1958, and 0.174 in at 20 deg on February 20, 1959. The increase in average gap of the tight rail indicates a loss of slippage resistance, the cause of which is not readily apparent as the bolts were tightened in August 1958, whereas the bolts in the normal rail were last tightened in November 1957.

Fig. 4 indicates the rail gap pattern for the tight and normal rail as obtained on August 26, 1959, at rail temperatures of 123 deg and 129 deg, respectively. The average gap for 211 joints in the tight rail was 0.001 in, the same as in the summer of 1958 when the rail temperature was 125 deg. There were six open joints with an average gap of 0.042 in compared with five open joints in 1958 with an average gap of 0.055 in. The average normal rail gaps decreased from 0.084 in. in 1958 to 0.070 in. in 1959 at comparable temperatures.

Rail movement, as shown in Figs. 1 and 3, for the tight and normal rail, respectively, indicates little change since the 1958 readings. The anchorage appears to be retaining its effectiveness.

Rail End Chipping

An examination of the rail ends developed that chipping was occurring at all except 51 of the joints in the tight rail test section. Considerable batter and flow existed at a number of the joints not then chipped and additional chipping may be expected soon. Of the badly battered and chipped joints, 65 should be considered for repair by welding at this time. Of these 65 approaching the welding stage, 10 were previously welded in 1957 when a total of 65 joints were welded in the test section. It is believed that the chipping has accelerated because the rail ends were undercut too much in an effort to insure a tight fit at the top of rail surface.

The normal rail is free of chipping and no batter of consequence was apparent at the time of inspection.

Maintenance of Way Report

No maintenance work was done by the L&N in the test sections during the last service period. Both tight rail and normal rail are in good line and surface, with the line being slightly better in the tight rail due to the more positive anchorage.

TIGHT RAIL TEST ON THE ERIE RAILROAD

Introduction

The Erie Railroad installed 1.74 miles of 115 RE tight rail in July 1957 in the eastward main track near Crown Point, Ind., using 6-hole long-toe bars, 13-in tie plates, 1-in track bolts with spring washers, and an initial bolt tension of 40,000 lb. A tension of 35,000 lb was used the following summer for retightening the bolts. The rail ends were hardened, beveled and milled with a slight undercut. The anchorage and other details of the installation, including the normal rail, are in the Proceedings, Vol. 59, 1958, page 1075.

The approximate tonnage over the test track was 6.3 million gross tons for the last service period and 14 million gross tons since establishing the test in September 1957. The test was last reported in the Proceedings, Vol. 60, 1959, page 841.

Rail Joint Gaps and Cumulative Rail Creepage

Winter rail gap and creepage readings were taken for the AAR-Erie test mile March 17, 1959. The results, as shown in Figs. 5, 6 and 7, indicated that the tight rail had very moderate movement, with the north rail showing no more than ⅛-in movement from its initial position. The normal rail, meanwhile, indicated considerable movement eastward, as much as 1 in. In the tight rail 218 of 266 joints were open with an average gap of 0.18 in at a temperature of 13 deg. This represents an increase of 51 open joints with an average gap increase for the open joints of 0.02 in at a temperature 9 deg above that for data taken December 11, 1957. Again the south rail showed six fewer open joints than the north rail because of the lower laying temperature.

The normal rail gaps measured 0.16 in at 16 deg compared to 0.21 in at 15 deg last winter, indicating resistance to movement had built up during the preceding service period. The normal rail gaps do not show good uniformity, especially in the north rail. Average winter joint gap for the normal rail was only 0.02 in larger than that for the tight rail.

Summer measurements of the gaps and creepage were recorded on July 5, 1959, with average rail temperatures of 119 deg on the tight rail and 118 deg on the normal rail.

In April 1959, after the last winter data had been taken, the Erie attempted to close up the gaps on the tight rail. At that time the rail clips were loosened in preparation for the work but because of continued high temperatures, the work was stopped. The rail moved considerably with the traffic during this period, as can be seen in Fig. 8 under tight rail creepage. The normal rail creepage pattern is consistent with that of last summer.

The tight rail had 27 open joints with an average gap of 0.08 in at 119 deg, as shown in Fig. 9. This is a decrease of 36 open joints compared to the previous summer data which was taken at 114 deg and had an average open joint gap of 0.07 in. The normal rail gaps averaged 0.029 in at 118 deg.

Fig. 10 demonstrates the effect of the lower rail laying temperature on the south rail, which had a slightly higher percentage of closed joints.

Maintenance of Way Report

The Erie plans to drive up the tight rail in the near future when temperature conditions permit. At this writing, there is no comparison of the costs of maintaining the tight rail. Complete data on the comparative expenses of the tight and normal rail will be shown in the next report.

TEST ON THE BESSEMER & LAKE ERIE RAILROAD

Introduction

The service test of tight rail on the B&LE near Grove City, Pa., was installed in October 1957 (See Vol. 59, page 1075). The rail is 140 RE with 140 AREA 6-hole head contact joints, bolt spacing 7–6–5½–6–7 in, 1⅛-in bolts and plain 11/64-in carburized washers.

The test was established by AAR staff members taking initial measurements of top-of-rail profile, joint gap, out-to-out of joint bars, bolt tension and rail creepage on November 20 and 21, 1957. Subsequent winter gap readings and creepage have been obtained by the B&LE. The AAR staff personnel has taken summer gaps and the remainder of the data at the close of each service period. Winter gap and rail creepage readings were last taken on January 23, 1959, and summer readings on July 16 and 17, 1959, when joint gaps, rail creepage and bolt tension were measured. Top-of-rail profiles and joint bar pull-in were not checked during the last service period.

The traffic for the last service period from August 11, 1958, to July 16, 1959, was 17 million gross tons, of which approximately 65 percent was southbound. The total tonnage from November 20, 1957, to July 16, 1959, was 23.8 million.

Bolt Tension Measurements

As stated in previous reports, the test was established with 45,000-lb bolt tension as a practical maximum for 1⅛-in bolts, and the power wrench was set for that tension in the initial and subsequent tightenings.

The six joints used for checking loss of tension were checked on July 17, 1959, with results as follows:

Average Bolt Tension in 1000 Lb

August 11, 1958 to July 17, 1959

Bolt Position	*Initial*	*Final*	*Loss*	*Percent Loss*
Middle bolts	45.7	29.5	16.2	35
Intermediate bolts	45.8	33.3	12.5	27
End bolts	45.2	34.0	11.2	25
Average all bolts	45.6	32.3	13.3	29

The losses of bolt tension above for a test period of 0.93 year compare favorably with the previous test period of 0.72 year when the losses were 43 percent for the middle bolts, 29 percent for the intermediate bolts and 33 percent for the end bolts. It is expected that the better retention of bolt tension will result in less openings of the rail gaps during periods of low temperatures.

Rail Joint Gaps and Creepage

Winter gap readings shown in Fig. 12 were obtained January 23, 1959, at 9 deg rail temperature. The average gap of the plain-end rail without beveling was 0.029 in compared with 0.051 in on February 10, 1958, at 2 deg. In the end-hardened and beveled rail, the average gap was 0.060 in compared with 0.075 in. in 1958. In the south one-

half mile there were 67 open joints averaging 0.055 in. in 1959 as against 104 open joints averaging 0.066 in. in 1958. The open joints in the north one-half mile increased from 127 in 1958 to 129 in 1959, but the average gap decreased from 0.081 in to 0.064 in.

The rail creepage at the time of the winter readings in 1959 (Fig. 11) indicates a slight movement into the test mile at each end, with an average of 0.125 in on the north end and 0.062 in on the south end. Movement elsewhere in the mile was slight.

The summer gap readings of July 16, 1959, are shown in Fig. 14. In the south one-half mile with plain-end rail, at an average rail temperature of 106 deg, only six open joints, with average gap of 0.033 in, were recorded. As noted, five of these were closed at the base and could not completely close at the running surface. In the north one-half mile 17 open joints had an average gap of 0.032 in at 118 deg. Of these open joints, 15 were closed at the base. In the summer of 1958, four joints in the south one-half mile and 14 joints in the north one-half mile were closed at the base. It is apparent that accurate milling is required to obtain a proper fit of the rail heads.

The rail creepage on July 17, 1959, shown in Fig. 13 followed a pattern similar to that in August 1958. The movement was out of the test mile at the ends, being an average of 0.19 in at the south end and 0.31 in at the north end. Movement at the intermediate points was nominal.

Chipping

The inspection in July 1959 developed that moderate chipping was occurring at 35 of the joints in the plain-end rail. The maximum size of chips was approximately ⅛ in wide and 1 in long. The chips are not of consequence at this time except that they do break the continuity of the rail surface. There was no evidence of chipping of the rail ends in the end hardened and beveled rail.

Maintenance

The only maintenance performed during the last test period was a general tightening of bolts in the entire test mile and resetting of the drive-on anchors in the north one-half mile during July 1959.

GENERAL REMARKS

In May 1959, 14 committee members and guests, including one from the AAR staff, inspected a two-mile installation of 132 RE rail laid tight in November 1956 on single-track main line of the L&N three miles south of Corbin, Ky. At approximately 100 F all rail ends were tight, and the contact of the rail heads was generally good, indicating a better job of end milling than that in the Chapel Hill test. Moderate chipping was noted, particularly on the low rail of the two curves within the test limits

From test information obtained in the foregoing tests, it is apparent that tight rail should be laid at mean temperatures if minimum gaps are to be maintained without excessive maintenance of high bolt tension. The chipping occurring on the L&N, and to a lesser degree on the B&LE plain-end rail, demonstrates that almost perfect rail-end matching is necessary together with maximum slippage resistance.

LABORATORY TESTS OF GLUED JOINTS

Foreword

With the cooperation of the American Railroad Curvelining Corporation, the Armstrong Cork Company and the Rail Joint Company, experimental tests were conducted in the Engineering Laboratory at the AAR Research Center in February 1959 to determine the effectiveness of glue to resist rail movements in the rail joints.

Static Tests

Joints for the tests were of 132 RE rail and 6-hole Rail Joint Company K-42 head-free bars with bolt tension of 20,000 lb. The glue was Armstrong Cork Company Bondarc VI. Glue was applied to the bearing surfaces of previously sandblasted bars and rails of four joints, which had been preheated to approximately 150 F. Immediately following application of the glue, each joint was assembled and the bolt tension applied with a torque wrench. In addition to the four glued joints, two control joints of standard 132 RE construction, using K-42 bars, were assembled with 20,000 lb bolt tension.

After allowing several days for the glue to set without postheating, pull tests were made in the CE laboratory of the Illinois Institute of Technology. One of the joints was omitted from the test because of too much heat in the rail and bars when the glue was applied, but the other three joints required 212,500 lb, 252,500 lb and 285,500 lb tension, respectively, or an average of 250,200 lb per joint to break the bond of the glued surfaces. The two control joints required 52,500 lb and 67,500 lb tension to overcome friction, or an average of 60,000 lb.

Rolling-Load Tests

Following the static tests, two glued joints were cleaned, sandblasted, reassembled with glue, as had been previously done, and tested in the 33-in stroke, rolling-load machine, following which they were given a pull test in the Illinois Institute of Technology Laboratory. The rail in one of the joints was end hardened and beveled whereas the other was plain end without hardening or beveling.

Each joint was subjected to 250,000 cycles of a 55,500-lb wheel load operating on the assembly supported at the ends of the bars, with a 36-in clear span. The bending moment ranged from 500,000 in-lb positive to 250,000 in-lb negative. Readings were taken to determine changes in bolt tension, rail end camber, joint gap and top of rail profile. Bolt tension, rail end camber and joint gaps remained constant in each joint throughout the 250,000 cycles. The average batter of the end-hardened joint was 0.007 in as compared to 0.004 in for the plain-end joint. This is not considered significant as there was 0.015 in difference in the height of rail ends of the hardened and beveled rails.

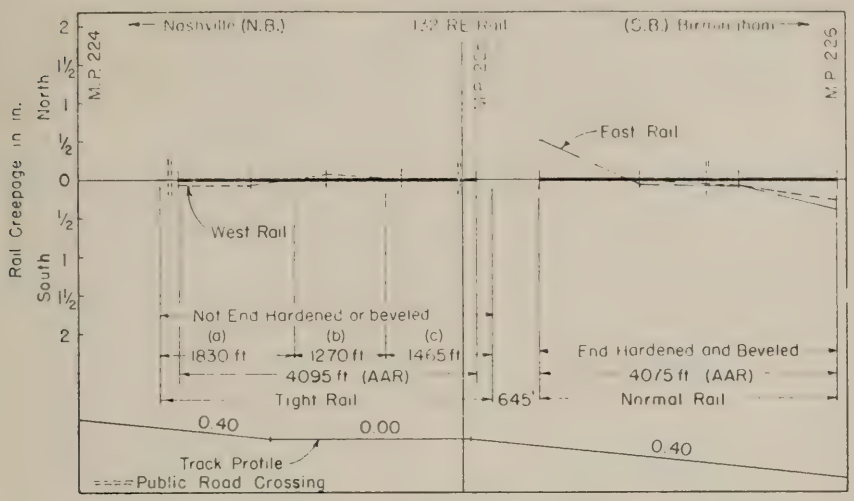
Following the operation in the rolling-load machine, the joints were given pull tests in the Illinois Institute Laboratory. The gripper stub failed on joint No. 6 at 212,500 lb and a similar failure occurred on joint No. 5 at 217,500 lb. There was no failure of the glue in either instance, hence it is believed that the operation in the rolling-load machine had little, if any, effect on the bond created by the glue.

Conclusions

From results obtained in the laboratory tests, it appears that epoxy resin glue has possibilities as an effective means of maintaining tight rail joints if applied under favorable conditions. The economics must be considered, but sufficient field installations have not been made to supply worthwhile cost data.

ACKNOWLEDGEMENT

The Association acknowledges the fine cooperation of the L&N, Erie and B&LE Railroads in connection with the field tests and appreciates the assistance given by the suppliers in conducting the glued joint tests. We appreciate the courtesy of the Illinois Institute of Technology in permitting the use of their testing machine for the pull tests.



Note: Rail laid tight is anchored with compression clips as follows: (a). Field end of all tie plates, except at the joints. (b). Field end of alternate tie plates (c). Gage end of alternate tie plates End zone anchorage consists of 8 track panels with all ties boxed, except at the joints. Normal rail is anchored with 8-8 grip type anchors boxed per rail.

Fig. 1. Rail Creepage, February 20, 1959, L & N RR, near Chapel Hill, Tenn.

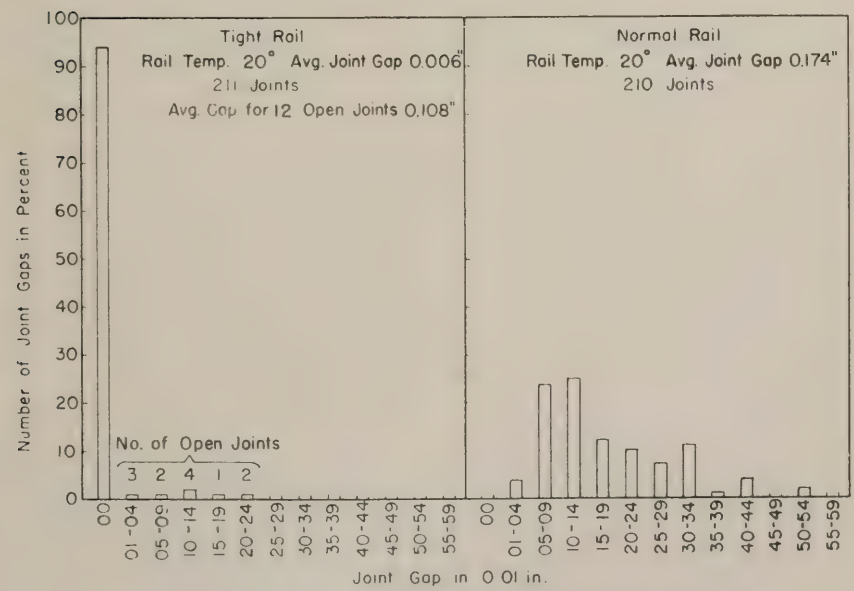
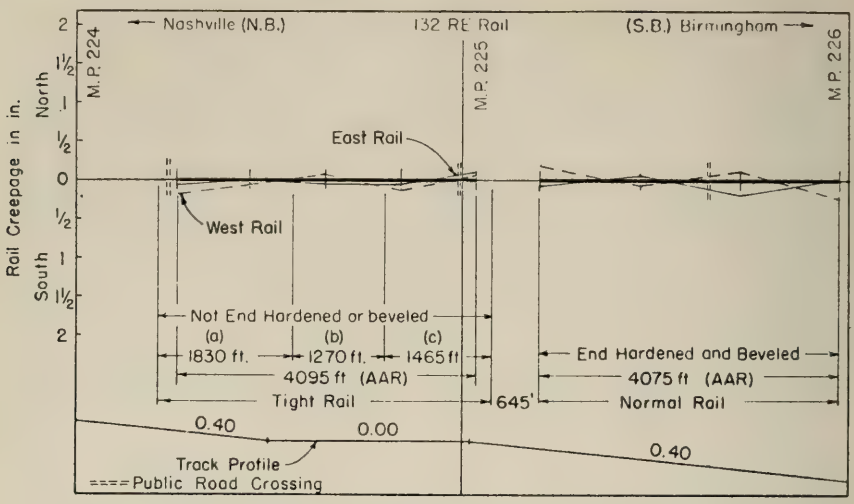


Fig. 2 Joint Gap Measurements for Tight and Normal Rail, February 20, 1959, L&N RR, near Chapel Hill, Tenn.



Note: Rail laid tight is anchored with compression clips as follows: (a). Field end of all tie plates, except at the joints. (b). Field end of alternate tie plates. (c). Gage end of alternate tie plates. End zone anchorage consists of 8 track panels with all ties boxed, except at the joints. Normal rail is anchored with 8-8 grip type anchors boxed per rail.

Fig. 3. Rail Creepage, August 26, 1959, L & N RR. near Chapel Hill, Tenn.

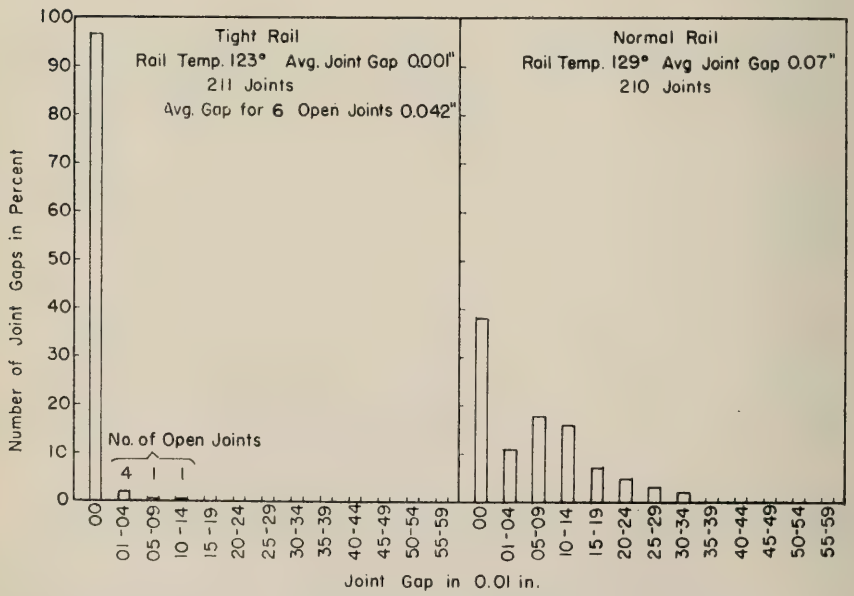
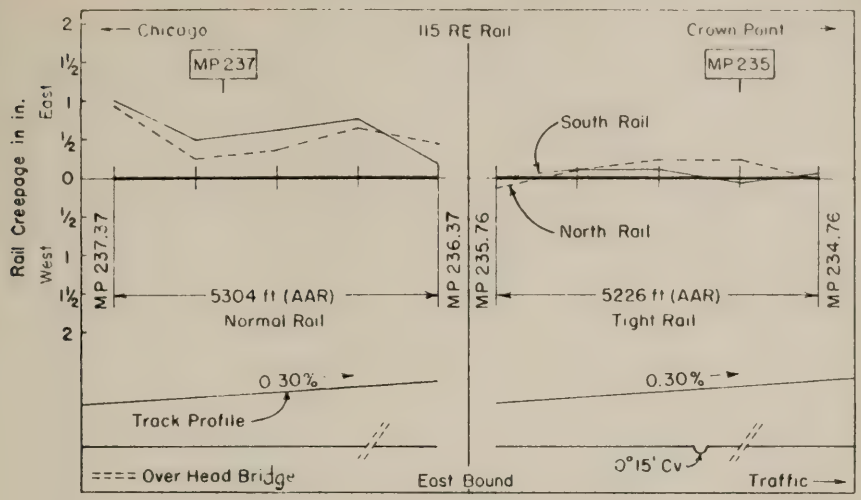


Fig. 4. Joint Gap Measurements for Tight and Normal Rail, August 26, 1959, L&N RR, near Chapel Hill, Tenn.



Note: Rail laid tight is anchored with 19 compression clips per rail. Normal rail is anchored with 8-2 grip type anchors per rail. All rail is end hardened and beveled.

Fig. 5. Rail Creepage, March 17, 1959, Erie RR, near Crown Point, Ind.

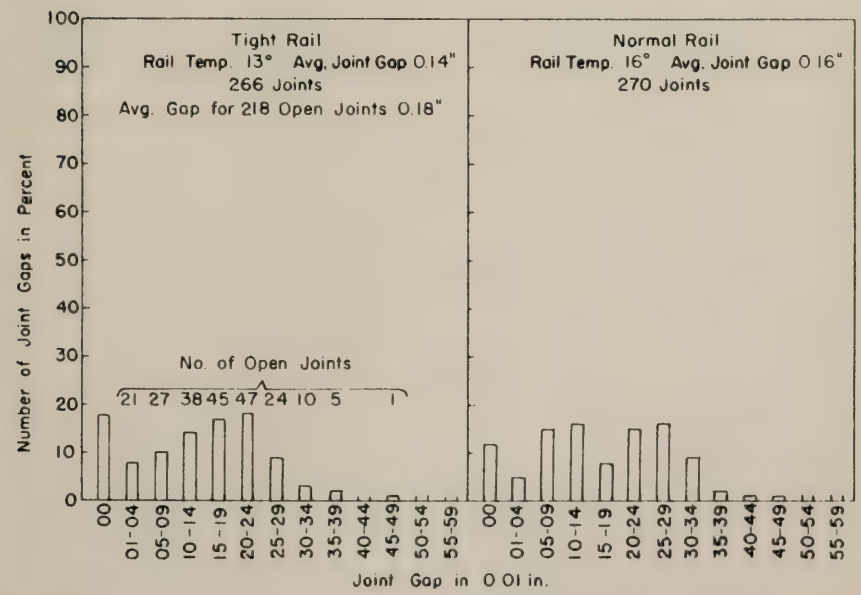


Fig. 6. Joint Gap Measurements for Tight and Normal Rail, March 17, 1959, Erie RR, near Crown Point, Ind.

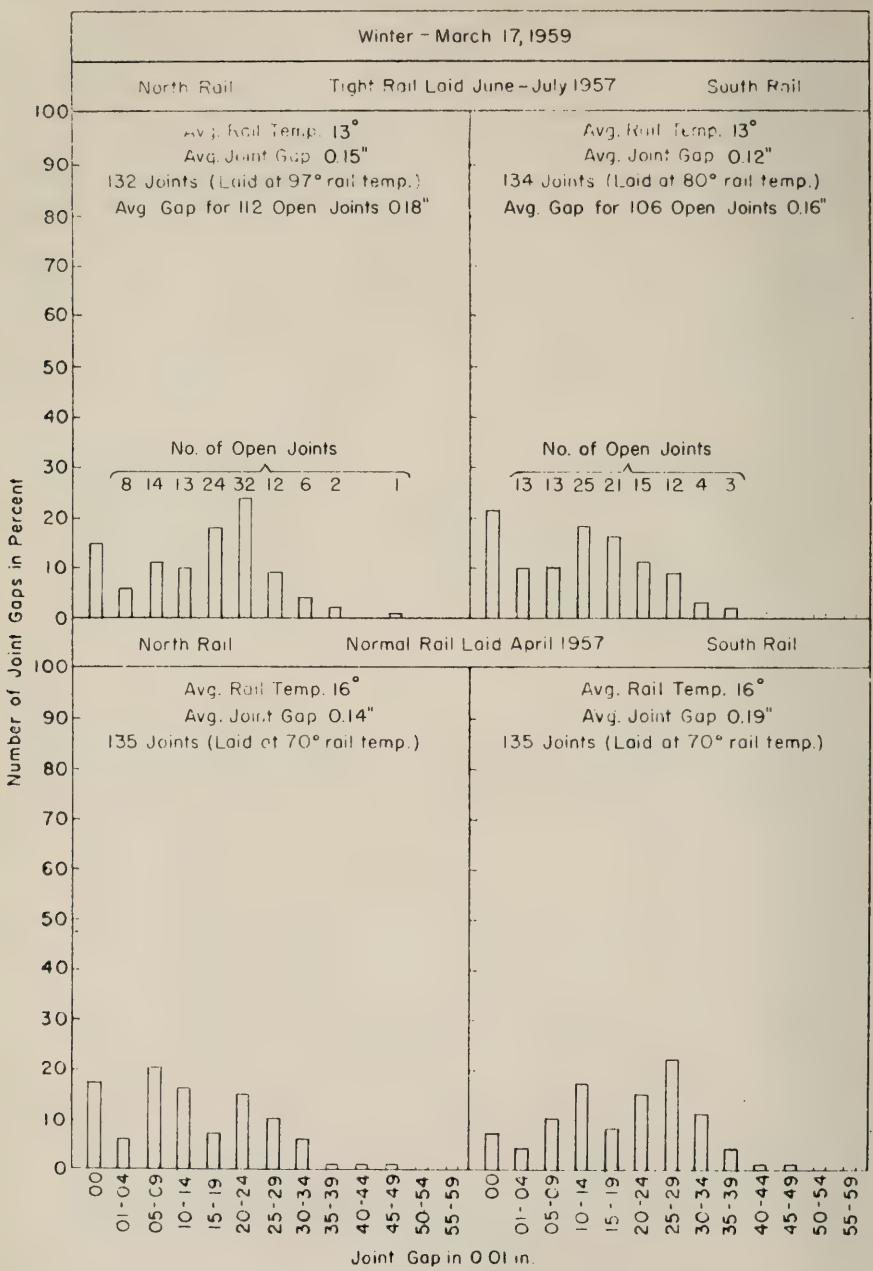
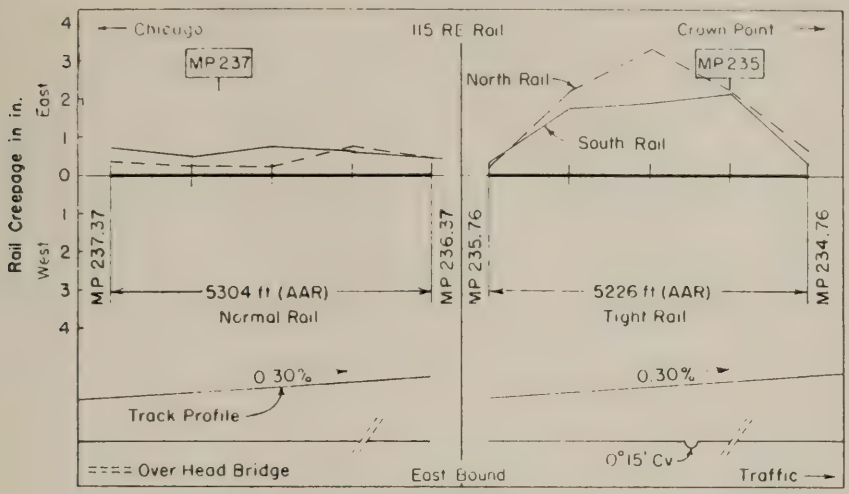


Fig. 7. Joint Gap Measurements in Tight and Normal Rail
Erie RR, near Crown Point, Ind.



Note: Rail laid tight is anchored with 19 compression clips per rail. Normal rail is anchored with 8-2 grip type anchors per rail. All rail is end hardened and beveled.

Fig 8 Rail Creepage, July 5, 1959, Erie RR, near Crown Point, Ind.

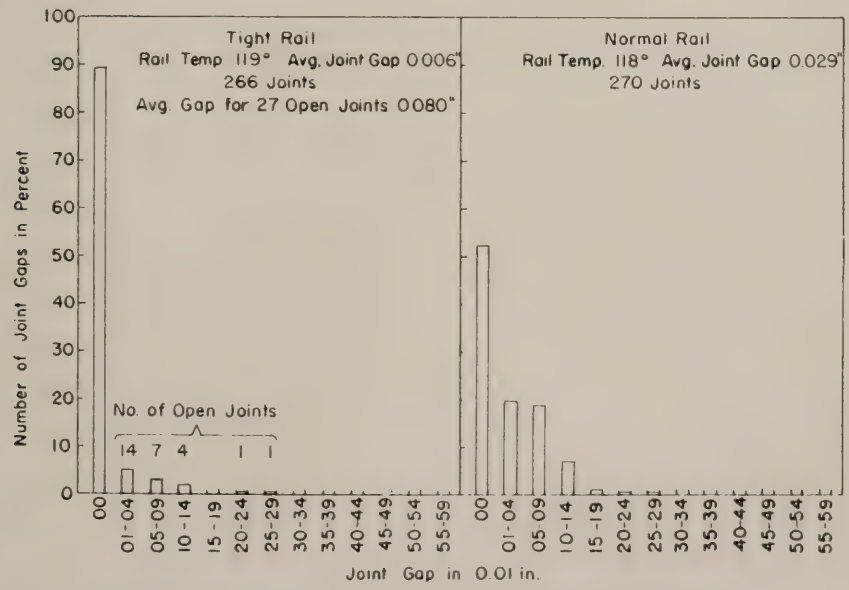


Fig 9. Joint Gap Measurements for Tight and Normal Rail, July 5, 1959, Erie RR, near Crown Point, Ind.

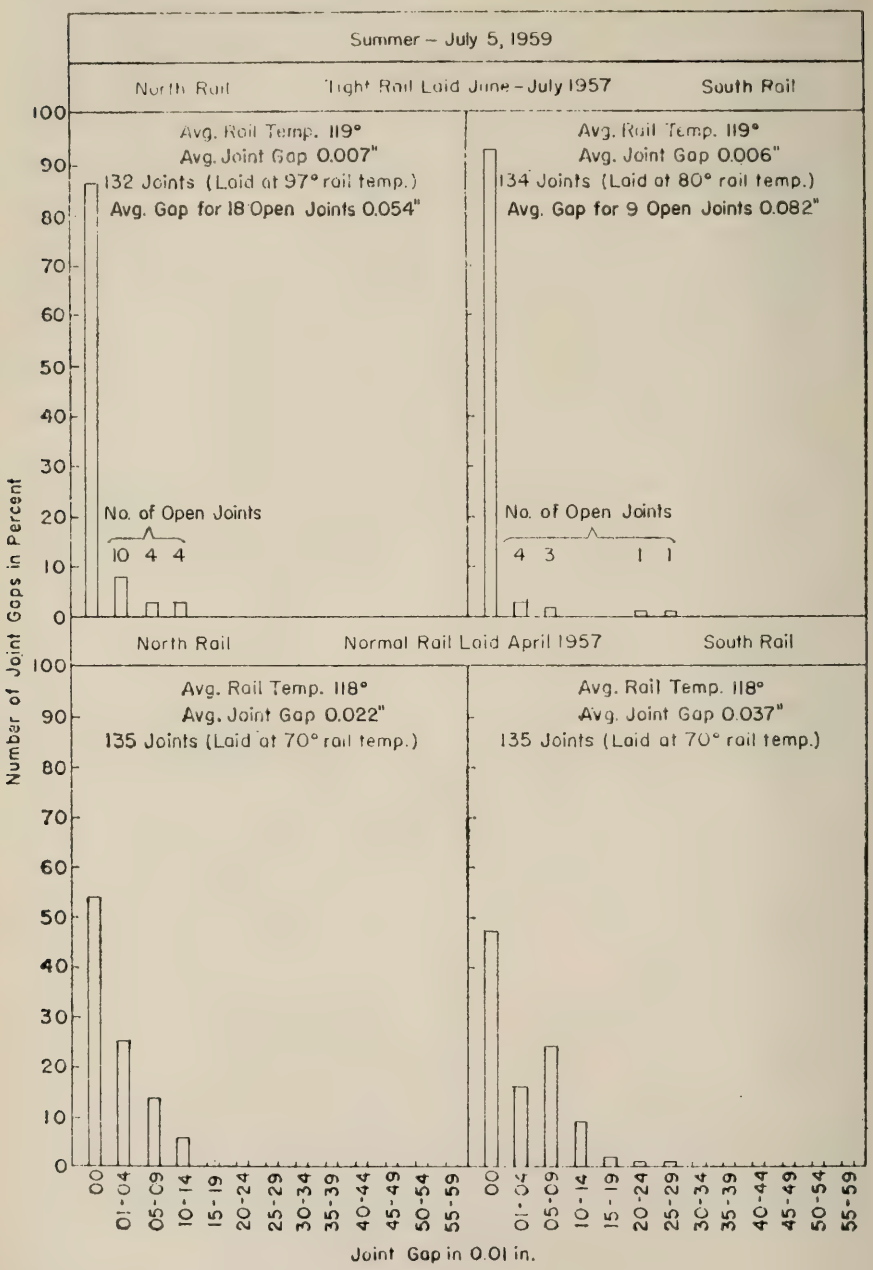
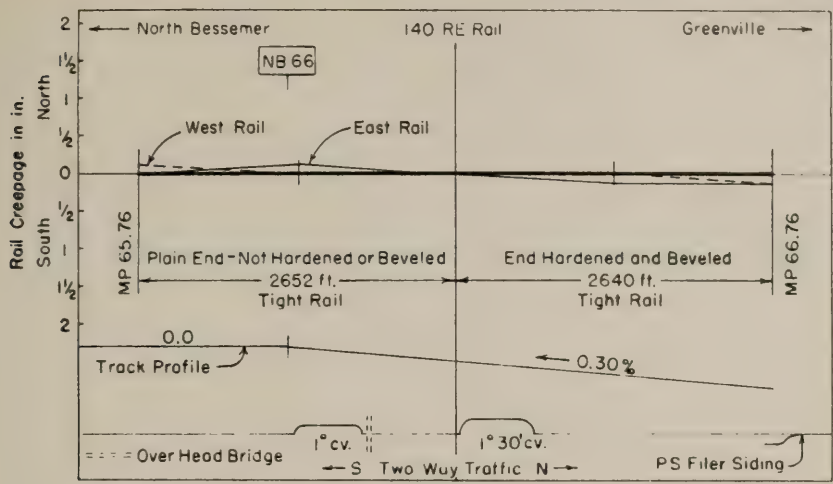


Fig. 10. Joint Gap Measurements in Tight and Normal Rail, Erie RR, near Crown Point, Ind.



Note Plain end rail – not hardened or beveled, is anchored with compression clips on every tie, alternately on gage and field side except at joints. End hardened and beveled rail is anchored with Fair anchors both rails, boxed every tie except at joints.

Fig. 11. Rail Creepage, January 23, 1959, B&LE RR, near Grove City, Pa.

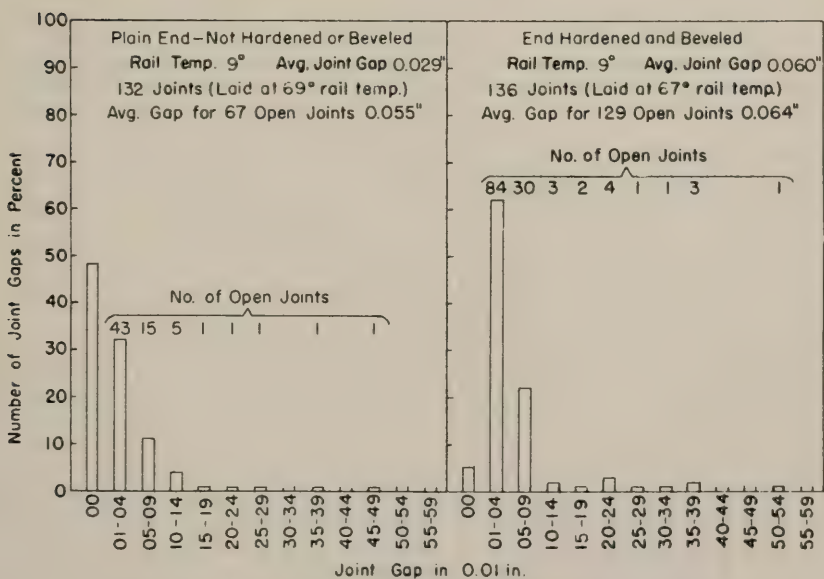
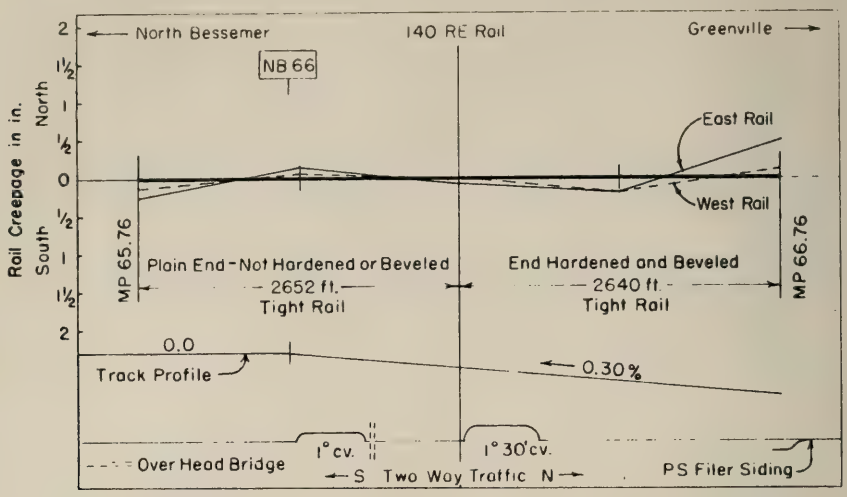


Fig. 12. Joint Gap Measurements for Plain End Rail – Not Hardened or Beveled and End Hardened and Beveled Rail, January 23. 1959 B&LE RR near Grove City, Pa.



Note Plain end rail – not hardened or beveled, is anchored with compression clips on every tie, alternately on gage and field side except at joints. End hardened and beveled rail is anchored with Fair anchors both rails, boxed every tie except at joints.

Fig. 13. Rail Creepage, July 17, 1959, B&LE RR, near Grove City, Pa.

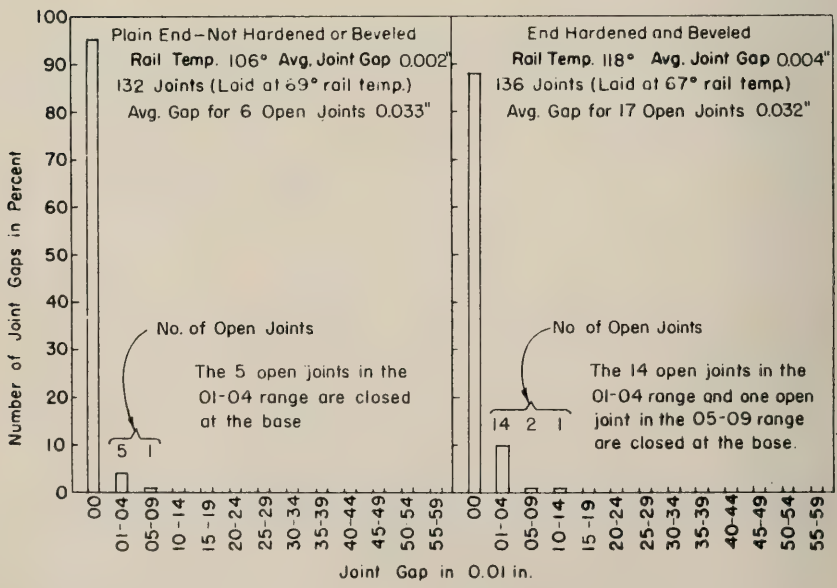


Fig. 14. Joint Gap Measurements for Plain End Rail – Not Hardened or Beveled and End Hardened and Beveled Rail, July 17, 1959, B&LE RR near Grove City, Pa.

Report on Assignment 10

Methods of Heat Treatment, Including Flame Hardening of Bolted Rail Frogs and Split Switches, Together with Methods of Repair by Welding

J. M. Salmon, Jr. (chairman, subcommittee), M. C. Bitner, F. W. Creedle, C. R. Fears, R. M. Frey, W. E. Griffiths, M. J. Hassan, A. E. Haywood, A. B. Hillman, Jr., A. E. Hinson, L. H. Jentoft, C. H. Johnson, A. A. Keever, T. R. Klingel, R. E. Kuston, L. W. Leitze, E. J. Lisy, Jr., S. H. Poore, R. P. Roden, R. D. Simpson, T. R. Snodgrass, R. E. Tew, K. H. Von Kampen, Troy West, D. J. White, I. V. Wiley.

SERVICE TESTS OF SIMULATED CROSSING UNITS IN THE MILWAUKEE RAILROAD AT MANHEIM, ILL.

This is a progress report, submitted as information.

Foreword

This service test in the westward freight main of the Milwaukee Road at Mannheim, Ill., was started April 13, 1954. After 91 million gross tons of traffic had passed over the simulated crossing flangeway units, all of the tread corners of the 24 units were built up by welding, September 9–11, 1957. The repair work was done in order to expedite the investigation as to the best welding techniques with respect to serviceability. Most of the units did not require the repair to meet the prevailing standard of maintenance. Since the welding, the units have carried approximately 71 million gross tons of traffic to September 10, 1959.

This subject for the period prior to the welding was included in the Proceedings, Vol. 59, 1958, page 1076, and was last reported in Vol. 60, 1959, page 862. A plan of a typical panel of eight units of bolted rail construction of the 132 RE section is shown on page 864 of Vol. 60.

The investigation is being conducted by the AAR research staff under the general direction of G. M. Magee, director of engineering research; H. E. Durham, research engineer track, is in direct charge of the investigation, assisted by members of his staff.

Maintenance of Units, Including Welding

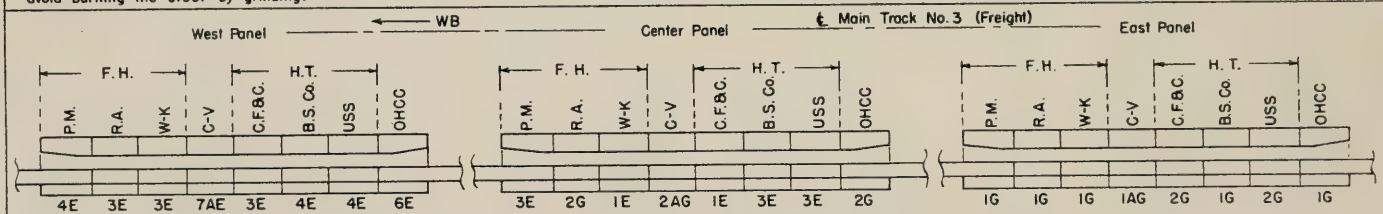
The original units installed in April 1954 were ground three times prior to welding in September 1957. The grinding was first done in April 1955, again in May 1956, and repeated in July 1957. Because of the false flanges on the treadworn wheels, the easer rail showed greater flow and generally required more grinding. Grinding was also necessary on the gage side of the running rails on some of the receiving arms and from between the running rail and the easer rail.

The welding of all the units was done after approximately 3½ years of service, primarily to develop one of the most important phases of the assignment*. Following this welding the units were ground to restore, as nearly as possible, the normal rail heights and surface contours. All of the units have been ground four times since the welding to prevent chipping and excessive flow, mostly on the easer rails. The grinding was done in November 1957, January 1958, June 1958, and again in October 1959.

* Details of the welding procedure and the materials used are described in Table 1 of this report. See page 949, Vol. 58, 1957, for chemical composition of the welding rods.

TABLE I. WELDING PROCEDURES FOR REPAIRING SIMULATED CROSSING UNITS ON THE MILWAUKEE ROAD AT MANNHEIM, ILLINOIS

(1). Pregrinding for all welding. Remove defective metal by grinding. (2). Finishing. Peen all gas welds while hot and finish by grinding after post heating if required when metal is cold. In electric welding lightly peen beads as deposited and finish by grinding after welding or post heating when the metal is cool. Care should be exercised to avoid burning the steel by grinding.



Location Plan of Test Units Showing Welding Procedures

Welding Procedure	Preheating	Description of Welding Rods	Post Treatment
1 G (a)	None	AIRCO RR rod, bare (Use 5%-10% carburizing flame)	None
1AG	do	do	Post-heat to 1000° F for 20 minutes
2G (a)	None	Oxweld M.W. rod, bare	None
2AG	do	do	Post-heat to 1000° F for 20 minutes
1E	Preheat to 350° F for 10 minutes	AIRCO No. 361 coated electrode	None
3E	Preheat to 500° F in temperate weather and to 550° F in cold weather	Teleweld Cro-Moly-Mang electrode Type 16 coating (GE S-32)	Post-heat to 800° F. Air cool in temperate weather. Blanket in cold or cool windy weather
4E	Preheat to between 300°F and 400°F	A. O. Smith Diamond-Weld A electrode	Post-heat to 700°-800°F as soon as welding is completed
6E	Preheat to 400° F	McKay E-973 coated electrode	None
7AE	Preheat to 500°-600° F	National Cyl. Gas Co. No. 170 RR rod with International Rail Weld Corp. coating	Post-heat with torch 20 minutes to 1000° F

Notes: P. M. = Pettibone Mulliken Corp. R.A. = Ramapo Ajax Division. W-K = Trackwork Division, Taylor-Wharton Iron & Steel Corp. C-V = Chrome-Vanadium alloy steel. C. F. & C. = Cleveland Frog & Crossing Co. B. S. Co. = Bethlehem Steel Company. USS = United States Steel Corp. OHCC = Open hearth control cooled rail, as rolled. F.H. = Flame hardened rail. H.T. = Heat treated rail. All rail temperatures are to be checked with Tempilstiks and recorded.

(a). When gas welding heat treated and flame hardened units, avoid overheating the base metal and apply the weld metal in small patches on the tread corners.

TABLE 2. PART 1. SUMMARY OF RAIL HEIGHT MEASUREMENTS AND BRINELL HARDNESS READINGS TAKEN ON THE THREE SIMULATED CROSSING INTERSECTION PANELS IN THE MILWAUKEE ROAD AT MANNHEIM, ILLINOIS

WEST PANEL — Test Period, May 31, 1957 through September 10, 1959

Designation of Unit	Welding Procedure*	Location	Rail Head Wear and Batter: Avg. Normal Wear in.	Wear Plus Batter in.	Batter Only in.	Brinell Hardness: Initial Before Traffic	After First Welding 9-11-57	9-10-59	Increase: Normal	F. W. Corner
Flame Hardened Rail										
Pettibone Mulliken Corporation	4E	Avg. Both Ends	.010			312		376	64	
		Rec. Cor.		.071	.061		302	342		40
		Lv. Cor.		.045	.035		321	371		50
Ramapo Ajax Div. American Brake Shoe Company	3E	Avg. Both Ends	.012			360		398	38	
		Rec. Cor.		.067	.056		327	315		-12
		Lv. Cor.		.038	.026		337	337		0
Weir-Kilby	3E	Avg. Both Ends	.010			328		384	56	
		Rec. Cor.		.084	.074		382	380		-2
		Lv. Cor.		.039	.029		321	335		14
Heat Treated Rail										
Cleveland Frog and Crossing Company	3E	Avg. Both Ends	.013			339		386	47	
		Rec. Cor.		.059	.046		351	340		-11
		Lv. Cor.		.038	.025		332	364		32
Bethlehem Steel Company	4E	Avg. Both Ends	.015			340		399	59	
		Rec. Cor.		.074	.059		340	335		-5
		Lv. Cor.		.044	.029		311	311		0
United States Steel Corporation	4E	Avg. Both Ends	.010			310		374	64	
		Rec. Cor.		.080	.070		332	321		-11
		Lv. Cor.		.035	.025		332	321		-11
Other Rails										
Used Chrome-Vanadium Rail	7AE	Avg. Both Ends	.010			366		378	12	
		Rec. Cor.		.066	.056		438	444		6
		Lv. Cor.		.037	.027		387	371		-16
C. C. Blue End Rail as Rolled	6E	Avg. Both Ends	.013			256		294	38	
		Rec. Cor.		.094	.081		266	361		95
		Lv. Cor.		.056	.043		292	375		123

Notes: All rail height measurements and Brinell readings were taken on the longitudinal center line of the running rail. The data taken 10 in. from both ends of each unit were used for determining the normal head wear and work hardening of the running rail. Rail head wear and batter of the tread corners were based on the readings taken 3/4 in. from the adjacent side of each flangeway. Values of batter of the tread corners cover the period from September 11, 1957 through September 10, 1959 for a gross tonnage of 71 million. Total tonnage for the 5.4 year service period is 162 million. See Table 2 for description of the welding procedures. See Vol. 59, 1958, page 1079-1082 for the test period prior to the first welding.

Units requiring the most grinding were: C-V, east and center; R-A, east panel; P-M, east panel; B. S. Company, east panel; OHCC, center panel. The following easer rails have broken at the flangeway: All 3 C-V units, 2 W-K, one USS and one Ramapo unit. These fractures were expected.

Rail Wear, Batter and Brinell Hardness

A complete summary of the rail head wear, batter and Brinell hardness readings for the test period May 31, 1957, through September 10, 1959, is presented in Table 2 in three parts. Batter on the flangeway corners covers the two-year period from September 11, 1957, to September 10, 1959. No wear or batter is presented prior to the 1957 dates.

The second part of the two-year cycle, i.e., from June 19, 1958, to September 10, 1959, has developed information for further evaluation of the welds in the area of the

TABLE 2. PART 2. SUMMARY OF RAIL HEIGHT MEASUREMENTS AND BRINELL HARDNESS READINGS TAKEN ON THE THREE SIMULATED CROSSING INTERSECTION PANELS IN THE MILWAUKEE ROAD AT MANNHEIM, ILLINOIS.

CENTER PANEL Test period, May 31, 1957 through September 10, 1959

Designation of Unit	Welding Procedure	Location	Rail Head Wear and Batter			Brinell Hardness				
			Avg. Normal Wear in.	Wear Plus Batter in.	Batter Only in.	Initial Before Traffic	After First Welding 9-11-57	9-10-59	Increase Normal	Increase F. W. Corner
Flame Hardened Rail										
Pettibone Mulliken Corporation	3E	Avg. Both Ends	.004			312		365	53	
		Rec. Cor.		.070	.066		302	321		19
		Lv. Cor.		.040	.036		311	332		21
Ramapo Ajax Div. American Brake Shoe Company	2G	Avg. Both Ends	.007			338		396	58	
		Rec. Cor.		.074	.067		347	344		-3
		Lv. Cor.		.026	.019		364	359		-5
Weir-Kilby	1E	Avg. Both Ends	.007			321		381	60	
		Rec. Cor.		.087	.080		359	364		5
		Lv. Cor.		.047	.040		269	347		78
Heat Treated Rail										
Cleveland Frog and Crossing Company	1E	Avg. Both Ends	.011			336		387	51	
		Rec. Cor.		.072	.061		293	382		89
		Lv. Cor.		.038	.027		217	375		158
Bethlehem Steel Company	3E	Avg. Both Ends	.014			337		398	61	
		Rec. Cor.		.065	.051		340	332		-8
		Lv. Cor.		.037	.023		321	340		19
United States Steel Corporation	3E	Avg. Both Ends	.012			338		394	56	
		Rec. Cor.		.082	.070		359	349		-10
		Lv. Cor.		.041	.029		321	340		19
Other Rails										
Used Chrome-Vanadium Rail	2AG	Avg. Both Ends	.006			362		374	12	
		Rec. Cor.		.091	.085		266	302		36
		Lv. Cor.		.019	.013		332	297		-35
C. C. Blue End Rail as Rolled	2G	Avg. Both Ends	.014			252		304	52	
		Rec. Cor.		.103	.089		302	332		30
		Lv. Cor.		.043	.029		340	356		16

receiving corner. In the flame-hardened group of Pettibone–Mulliken, Ramapo Ajax and Weir Kilby, the electric weld technique designated 3E (see Table 1) sponsored by Teleweld, appeared to be performing well, especially on the Ramapo unit. The receiving corner batter of this section was 0.055 in for the two-year period (see Table 2, part 1). During this time the Brinell hardness decreased slightly on the receiving corner. Other effective welds in this group were A. O. Smith (4E), recommended by B. S. Company for heat treated rail, on the Pettibone–Mulliken; Oxweld (2G) on the Ramapo Ajax; and Airco No. 361 (1E) on the Weir Kilby unit.

In the heat-treated group of Cleveland Frog and Crossing, Bethlehem Steel, and United States Steel, the Teleweld (3E) welds again were performing well, particularly on the Cleveland and Bethlehem units, which had 0.046 in and 0.051 in batter, respectively, for the two-year period. Again the hardness on these sections had reduced moderately on the receiving corners. Other welds which have shown up favorably are Airco 361 (1E) on the CF&C, A. O. Smith (4E) on the B. S. and USS units.

The National Cylinder Gas electric weld (7 AE) has shown the best results on the used chrome–vanadium rail. The electric weld in this case seems to be superior to the gas

TABLE 2. PART 3. SUMMARY OF RAIL HEIGHT MEASUREMENTS AND BRINELL HARDNESS READINGS TAKEN ON THE THREE SIMULATED CROSSING INTERSECTION PANELS IN THE MILWAUKEE ROAD AT MANNHEIM, ILLINOIS

EAST PANEL Test Period, May 31, 1957 through September 10, 1959

Designation of Unit	Welding Procedure	Location	Rail Head Wear and Batter			Brinell Hardness				
			Avg. Normal Wear in.	Wear Plus Batter in.	Batter Only in.	Initial Before Traffic	After First Welding 9-11-57	9-10-59	Increase Normal	Increase F. W. Corner
Flame Hardened Rail										
Pettibone Mulliken Corporation	1G	Avg. Both Ends	.011			296		349	53	
		Rec. Cor.		.095	.084		302	327		25
		Lv. Cor.		.034	.023		302	321		19
Ramapo Ajax Div. American Brake Shoe Company	1G	Avg. Both Ends	.014			344		407	63	
		Rec. Cor.		.112	.098		327	338		11
		Lv. Cor.		.038	.024		302	302		0
Weir-Kilby	1G	Avg. Both Ends	.017			303		373	70	
		Rec. Cor.		.133	.116		317	311		-6
		Lv. Cor.		.053	.036		321	347		26
Heat Treated Rail										
Cleveland Frog and Crossing Company	2G	Avg. Both Ends	.011			329		394	65	
		Rec. Cor.		.084	.073		351	340		-11
		Lv. Cor.		.028	.012		347	396		49
Bethlehem Steel Company	1G	Avg. Both Ends	.011			353		394	41	
		Rec. Cor.		.093	.082		262	319		57
		Lv. Cor.		.036	.025		293	321		28
United States Steel Corporation	2G	Avg. Both Ends	.012			304		376	72	
		Rec. Cor.		.094	.082		321	327		6
		Lv. Cor.		.028	.016		387	438		51
Other Rails										
Used Chrome Vanadium Rail	1AG	Avg. Both Ends	.011			361		381	20	
		Rec. Cor.		.108	.092		286	307		21
		Lv. Cor.		.038	.027		259	297		38
C. C. Blue End Rail as Rolled	1G	Avg. Both Ends	.013			246		290	44	
		Rec. Cor.		.075	.062		293	282		-11
		Lv. Cor.		.028	.015		293	286		-7

welds. On the OHCC units, the Airco (1G) gas weld in the east group has shown consistently good results.

In most cases the rate of batter had decreased during the last test period. In general for each group, except the OHCC, the receiving corner batter was greater for the gas welds than for the arc welds. Gas weld 1G had the least receiving corner batter on the OHCC units. In some cases, the welded OHCC sections were performing as well as, if not better than, the used chrome–vanadium and some of the flame-hardened units.

Brinell hardness readings on the flangeway corners at the end of this service period continued the same trends for the most part as shown in the period immediately after the welding. The values have leveled off and apparently have reached an equilibrium condition. From the hardness readings on the tread corners (Table 2), there was no correlation between the amount of tread corner batter and the Brinell hardness of the weld metal taken immediately after the welding or the increase in hardness during the two-year test period. In the case of gas welds, which generally had more receiving corner batter than the arc welds, it is possible that the heat affect on the parent metal

caused the rail head to soften to the extent of contributing to more apparent batter due to compressing the metal under the welds.

There has been no failure of the welds, but some have developed more batter than others. This indicates a trend, and possibly a few of the tread corners will require repair by welding after another year of service.

Acknowledgement

The Association is indebted to the Milwaukee Road and the sponsors of the various test units and welding techniques for their cooperation and assistance in conducting this investigation.

PROCEEDINGS

A

PROGRAM

Fifty-Ninth Annual Meeting
Sherman Hotel, Chicago

Monday, March 14

Morning Session—Grand Ballroom—9:00 to 12:00

Invocation—Rev. Herschel Allen, Associate Minister, First Presbyterian Church, Evanston, Ill.

Introductions and Greetings.

Presidential Address—F. R. Woolford, Chief Engineer, Western Pacific Railroad.

Report of Executive Secretary—Neal D. Howard.

Report of Treasurer—A. B. Hillman, Retired Chief Engineer, Chicago & Western Indiana and Belt Railway of Chicago.

Greetings from the Signal Section, AAR, V. O. Smeltzer (Chairman), Superintendent Signals System, Atchison, Topeka & Santa Fe Railway.

Greetings from the Electrical Section, AAR, J. J. Schmidt (Chairman), Electrical Research Engineer, Denver & Rio Grande Western Railroad.

Greetings from the National Railway Appliances Association, J. B. Templeton (President), President, Templeton, Kenly & Co.

Keynote Address—Main Lines Toward Better Railroads, by C. D. Buford, Vice President, Operations and Maintenance Department, AAR.

Symposium on Standardization

Standardization—A Tool to Greater Industrial Efficiency, by Norman L. Mochel, Manager, Metallurgical Engineering, and Consultant, Westinghouse Electric Corporation.

Standardization—Can Effect Huge Savings for the Railroads, by J. S. Fair, General Purchasing Agent, Pennsylvania Railroad.

Standardization—As the Trackwork Manufacturers See It, by J. P. Kleinkort, Manager, Railroad Products Division, American Brake Shoe Company.

Standardization—From the Standpoint of the Engineering and Maintenance of Way Departments, by R. H. Beeder, Chief Engineer System, Atchison, Topeka & Santa Fe Railway.

Address—The Responsibilities of Maintenance—Officers to Their Managements, by D. W. Brosnan, Vice President—Operations, Southern Railway System.

Afternoon Session—Grand Ballroom—1:30 to 5:30

Reports of Committees	Bulletin Numbers
28—Clearances (1:30)	554

Motion Picture—"Freight Car Clearance Tests on DL&W RR", with commentary by Randon Ferguson, Electrical Engineer, Research Staff, AAR.

Address—The Engineering Profession Comes of Age, by H. A. Mosher, President, National Society of Professional Engineers.

Address—Oil Pipe Lines on Railroad Rights of Way (illustrated), by W. T. Eskew, Jr., Assistant General Manager, Southern Pacific Pipe Lines, Inc.

20—Contract Forms (2:55) 553

Address—The Relationship Between the Attorney and the Engineer on the Railroad, by Henry W. Oppenheimer, General Attorney, Chesapeake & Ohio Railway.

11—Engineering and Valuation Records (3:25) 555

Symposium on Depreciation and Its Impact on Budgets and Maintenance Expenditures, L. W. Howard, Land and Tax Commissioner, Chicago & Western Indiana and Belt Railway of Chicago, Moderator.

From the Viewpoint of the Valuation Engineer—Morton Friedman, Retired Chief Valuation Engineer, New York Central System.

From the Viewpoint of the Engineer Maintenance of Way—J. Bert Byars, Assistant to Chief Engineer, Denver & Rio Grande Western Railroad.

From the Viewpoint of the Chief Engineer—E. W. Smith, Assistant to Chief Engineer, St. Louis–San Francisco Railway.

14—Yards and Terminals (4:03) 553

Motion Picture on the P&LE's new retarder yard near Youngstown, Ohio —"The New Gateway", with commentary by E. G. Brisbin, Chief Engineer, Pittsburgh & Lake Erie Railroad.

16—Economics of Railway Location and Operation (4:40) 553

Address—Operating Innovations—Present and Future (illustrated), by M. I. Dunn, Vice President—Operations, Chesapeake & Ohio Railway.

25—Waterways and Harbors (5:18) 553

Tuesday, March 15

Morning Session—George Bernard Shaw Room—8:30 to 11:55

Reports of Committees — Bulletin Numbers

13—Water, Oil and Sanitation Services (8:30) 553

24—Cooperative Relations with Universities (8:50) 555

Address—The Career Development of Engineers on Seven Railroads, by V. J. Roggeveen, Associate Professor of Civil Engineering and Transportation, Stanford University.

7—Wood Bridges and Trestles (9:25) 555

Address—Fire-Retardant Treatments on the Santa Fe (illustrated), by L. C. Collister, Manager, Tie and Timber Treating Department, System, Atchison, Topeka & Santa Fe Railway.

8—Masonry (10:00) 554

Symposium on Prestressed Concrete. (To be presented with report of Committee 30).

30—Impact and Bridge Stresses (10:15) 554

Symposium on Application of Prestressed Concrete to Railway Structures (illustrated), E. J. Ruble, Research Engineer Structures, AAR, Moderator. (Jointly with Committee 8).

Research—Dr. C. E. Ekberg, Jr., Professor and Head, Department of Civil Engineering, Iowa State University.

Material—L. P. Nicholson, Railway Representative, Portland Cement Association.

Design—W. R. Wilson, Assistant Bridge Engineer System, Atchison, Topeka & Santa Fe Railway.

Construction—P. S. Gillan, General Manager, Florida Prestressed Concrete Company.

15—Iron and Steel Structures (11:05) 555

Address—Construction and Loading of Half-Scale Test Bridge at Northwestern University (illustrated), by Gerald C. Ward, Civil Engineering Administrative Director, Truss Bridge Research Project.

Address—Truss Bridge Research Program and Current Results (illustrated), by John F. Ely, Acting Director, Truss Bridge Research Project.

29—Waterproofing (11:45) 554

ASSOCIATION LUNCHEON—GRAND BALLROOM, 12 NOON

Presentation of those at Speaker's tables.

Presentation of gavels to incoming committee chairmen.

Announcement of results of election of officers.

Address by Frederic B. Whitman, President, Western Pacific Railroad, on The Challenge for Progress.

Afternoon Session—George Bernard Shaw Room—2:15 to 5:30

Reports of Committees	Bulletin Numbers
6—Buildings (2:15)	553
Address—Control Joints in Masonry Block Construction, by W. C. Panarese, Railways Representative, Portland Cement Association.	
9—Highways (2:45)	553
Address—Federal-Aid Highways and the Railroads—A Status Report, by Bertram D. Tallamy, Federal Highway Administrator, Bureau of Public Roads.	
17—Wood Preservation (3:30)	554
3—Ties (3:45)	554

27—Maintenance of Way Work Equipment (4:05) 554

Panel Discussion—Work Equipment Operators and Mechanics, R. K. Johnson, Superintendent of Work Equipment and Reclamation, Chesapeake & Ohio Railway, Moderator.

Panel Members: G. R. Collier, Gulf, Colorado & Santa Fe Railway. F. L. Etchison, Western Maryland Railway. Paul Martin, New York Central System. V. W. Oswalt, Jr., Central of Georgia Railway. J. W. Risk, Canadian National Railways. W. B. Blix, Nordberg Manufacturing Company. C. H. Johnson, Fairmont Railway Motors, Inc. Royce Kershaw, Kershaw Manufacturing Company. P. S. Settle, Railway Maintenance Corporation. M. S. Westlund, Jackson Vibrators, Inc.

22—Economics of Railway Labor (4:50) 554

Motion Picture—"Mechanized Bridge and Building Gangs", with commentary by R. L. Fox, Process Engineer Structures, Southern Railway System.

Wednesday, March 16

Morning Session—Grand Ballroom—8:30 to 12:00

Report of Committees — Bulletin Numbers

1—Roadway and Ballast (8:30) 556

Address—Highlights of Asphalt Treatment of Ballast (illustrated), by G. L. Hinueber, Engineering Laboratory Manager, AAR.

4—Rail (9:15) 556

Address—Wheel Load, Wheel Diameter and Rail Damage (illustrated), by C. J. Code, Assistant Chief Engineer—Staff, Pennsylvania RR.

Special Committee on Continuous Welded Rail (9:50) 556

Motion Picture—"The Rio Grande's Big Push."

Motion Picture—"Field Loading Welded Rail" on the Santa Fe.

5—Track (10:30) 556

Panel Discussion—Standardization of Track Turnouts, S. H. Poore, Assistant Engineer, Chesapeake & Ohio Railway, Moderator.

Panel Members: M. C. Bitner, Manager—Methods and Cost Control, Pennsylvania Railroad. F. W. Creedle, Chief Engineer, Trackwork Products, Railroad Products Division, American Brake Shoe Company. T. R. Klingel, Chief Engineer, Minneapolis, St. Paul & Sault Ste. Marie Railroad. M. J. Zeeman, Engineer of Track Design, Atchison, Topeka & Santa Fe Railway.

Closing Business (11:30)

Installation of Officers.

Adjournment. (12 noon)

Afternoon—1:30

Post-convention inspection of AAR Research Center.

Report of the Tellers
March 15, 1960

We, the Committee of Tellers, appointed to canvass the ballots for officers and for members of the Nominating Committee, find the count of the ballots as follows:

For President

E. J. Brown 1,657

For Senior Vice President

R. H. Beeder*

For Junior Vice President

C. J. Code 1,646

For Directors (first four men elected)

C. J. Henry 1,029
J. M. Trissal 962
W. B. Throckmorton 877
J. A. Bunjer 841
T. B. Hutcheson 816
V. C. Hanna 684
W. D. Kirkpatrick 679
H. J. Fast 623

For Members of Nominating Committee (first five men elected)

A. L. Sams 992
B. H. Crosland 976
W. H. Huffman 971
W. J. Jones 947
L. S. Crane 864
A. W. Munt 733
L. C. Collister 699
A. S. Krefting 666
F. A. Hess 655
R. L. Milner 565

THE COMMITTEE OF TELLERS,
J. E. WIGGINS, *Chairman.*

R. C. BAKER
C. M. BARDWELL
R. A. BARDWELL
R. O. BARDWELL
I. C. BROWN
L. E. CONNER
D. W. CONVERSE
E. H. COOK
F. C. CUNNINGHAM
C. E. DEGEER
RAYMOND DEJAIFFE
WM. J. DIXON
J. J. DWYER
R. E. ENDERLE
R. J. FISHER
C. J. GEYER
E. L. GLOVER
R. S. GLYNN
R. R. GUNDERSON
E. C. HARRIS
C. I. HARTSELL
E. J. HEFFERMAN
F. W. HUTCHINSON
B. J. JOHNSON
F. O. KLEMSTINE
RAY MCBRIAN
G. T. METZDDRF
B. R. MEYERS
H. C. MINTEER
L. R. MORGAN
E. T. MYERS
C. H. NEWLIN
V. W. OSWALT
W. C. PINSCHMIDT
J. R. RUSHMER
R. L. SAMUELL
G. L. SARSFIELD
M. M. STANSBURY
T. A. TENNYSON
C. B. VOITELLE
R. E. VON SPRECKEN
R. D. WHITE
G. L. ZIPPERIAN

* Under provisions of the Constitution, R. H. Beeder advances automatically from junior vice president to senior vice president.

PROCEEDINGS

Running Report of the Annual Meeting of the American Railway Engineering Association (Construction and Maintenance Section, Engineering Division, Association of American Railroads), March 14–16, 1960, Hotel Sherman, Chicago, Including Abstracts of All Discussions, All Formal Action on Committee Presentations, Specific Papers and Addresses Presented in Connection with Committee Reports, and Other Official Business of the Association

Opening Session, March 14, 1960

President F. R. Woolford* Presiding

The opening session of the 59th Annual Meeting convened at 9:00 am.

Executive Secretary Neal D. Howard: Gentlemen, President Woolford has asked me at this time, before he assumes the podium, to invite to the speaker's table our guests at the opening session. Those who are to sit at the head table will see their names there. I wish they would please take their places at this time so we can begin shortly.

While these gentlemen are coming to the speaker's table, may I suggest that any of you who are to attend Committee luncheons today secure your tickets, preferably before the session starts, because it is imperative that the hotel know how many will attend the luncheons.

There is just one other thing. I wish those in the back room would please quickly take places in chairs.

Again, the Sherman Hotel desires to present our president with a gavel. This presentation will be made by Mr. Daniel Amico, vice president of the Sherman Hotel, and if Mr. Amico is here, I wish he would come forward and present the gavel so Mr. Woolford can get the meeting started. Mr. Amico.

Mr. Amico: Mr. Chairman, members of the American Railway Engineering Association, and guests:

Welcome to Chicago and, of course, welcome back to the Sherman Hotel. On behalf of our 2000 employees, we hope you will have a wonderful meeting and enjoy yourself in our great city. At this time I would like to present a gavel to your president, Mr. Woolford, as a token of remembrance. It is our hope that as the last sound of this gavel occurs, the American Railway Engineering Association will have had the best convention in its history.

President Woolford: Thank you, Mr. Amico. I certainly appreciate the beautiful token you have given me as the president of the American Railway Engineering Association. I want to express to you the thanks of myself and our whole Association for the pleasing way you handled the conventions we have held in your hotel in the past. I know this one will be equal to them, if not better.

I will now use this beautiful gavel which has just been presented to me by Mr. Amico to officially open this, the 59th Annual Meeting of the American Railway Engineering Association and the 39th Annual Meeting of the Construction and Maintenance Section of the Engineering Division of the Association of American Railroads.

Chief Engineer, Western Pacific Railroad.

Before beginning the heavy program of work ahead of us for the next two and one-half days, I believe it would be most appropriate for us to look to our Supreme Commander for guidance. Accordingly, I have asked the Rev. Herschel Allen, associate pastor of the First Presbyterian Church of Evanston, Ill., to invoke divine guidance and help for us in our deliberations. Rev. Allen.

Invocation

Rev. Allen: May we join in prayer. Almighty and ever-living God, Who alone art the Foundation and Engineer of all that is ultimately worth while and eternally lasting, we look to Thee and ask Thy blessing upon the works and men of this convention. We know that Thou canst not bless all that we have undertaken to do in the past, nor can we presume Thy blessing upon all that we would undertake to do in these days. Nevertheless, we ask that Thy Presence may be so felt among us that we may be guided by Thy deep and abiding truths.

We ask, O God, Thy blessing upon those who have prepared this convention and those who will be taking places of leadership throughout it. We ask that Thou wilt bless those who will be officers during the coming year, that Thou wilt guide and enrich them and, through them, enrich the work of this Association.

We ask, O God, as men created in Thy image, that Thou wilt enable us to find purposes worthy of our best efforts, that Thou wilt grant us goals worthy of the investment of our time and energy. In all our works, O God, we ask that we may not forget our responsibilities as men of families. We ask that we may return to our homes with a renewed commitment to be better husbands and fathers, and that through our engineering efforts, better families, better people, a more worthwhile country may be built. We ask it in Jesus' name. Amen.

President Woolford: Thank you, Reverend Allen. Your very appropriate petition in our behalf gives us all, I am sure, a sense of assurance and strength as we begin our deliberations. If it is possible for you to remain with us for a while, we would be most pleased to have you do so and see what makes railroad engineers click. However, please feel free to leave at any time you choose. Thank you again, Reverend Allen, for your guidance at our opening this morning.

We meet here today in pleasant and familiar surroundings. Our host hotel provides splendid facilities for our activities, and its management and personnel have assured us of every courtesy and service during our stay. This, combined with the long and careful planning on the part of your officers and directors, your secretary's office and your Committee on Convention Arrangements, assures us another most pleasant, successful and profitable meeting.

As you know, there is no exhibit of the National Railway Appliances Association in connection with our convention this year, but I am pleased to see many of our railway supply friends here with us. I know you will want to discuss many of your material and equipment problems with them, and I hope you will take every available opportunity to do so.

I am pleased to see that many of you, members and railway supply friends, have brought your wives with you to the convention. I welcome the ladies who are here with us this morning in the balcony. I want you ladies to know that we shall be happy to have you sit in on any of our sessions, whether here in the Grand Ballroom or in the George Bernard Shaw Room, and we hope you will do this, coming and going as you may desire, to hear any particular addresses or committee presentations. I particu-

larly invite you to be present at the closing business session of our convention in this room on Wednesday, beginning about 11:30 am, when our newly elected officers will be installed. In the meantime, I hope you will enjoy to the fullest the social functions which have been arranged for you and that you will have a most pleasant stay here in Chicago.

Without an exhibit this year, it is hardly to be expected that the attendance at this convention will equal that of previous exhibit years, but every indication is that we will have a large attendance. One of these indications is the fact that a total of 343 members and guests registered yesterday between 10:00 am and 3:00 pm, during the advance registration of those who came early to participate in certain pre-convention activities. The names of those who registered yesterday will appear in the first of the three Daily Registration Lists to be published by the Association, which will be available to all of you shortly.

Without further delay, I would like to present to you those sitting at our speaker's table. As I introduce each one, I will appreciate his standing momentarily to be recognized. While I know you would like to applaud each one, may I ask that you refrain from doing so, reserving your applause until all have been introduced.

Mr. B. R. Meyers, past president of AREA, 1958–1959; vice president and chief engineer, Chicago & North Western Railway, Chicago.

Mr. Ray McBrian, past president of AREA, 1957–1958; director of research, Denver & Rio Grande Western Railroad, Denver, Colo.

Mr. Wm. J. Hedley, past president of AREA, 1956–1957; chief engineer, Wabash Railroad, St. Louis, Mo.

Mr. G. M. O'Rourke, past president of AREA; retired assistant engineer maintenance of way, Illinois Central Railroad, Chicago.

Mr. G. W. Miller, past president of AREA; assistant general manager (special duties), Canadian Pacific Railway, Toronto, Ont.

Mr. C. J. Geyer, past president of AREA; retired vice president construction and maintenance, Chesapeake & Ohio Railway, Richmond, Va.

Mr. T. A. Blair, past president of AREA; retired chief engineer system, Atchison, Topeka & Santa Fe Railway, Park Ridge, Ill.

Mr. C. H. Mottier, past president of AREA; retired vice president, Illinois Central Railroad, Chicago.

Mr. Neal D. Howard, executive secretary of AREA.

Mr. E. J. Brown, senior vice president of AREA; chief engineer, Burlington Lines, Chicago.

Mr. R. H. Beeder, junior vice president of AREA; chief engineer system, Atchison, Topeka & Santa Fe Railway, Chicago.

Mr. A. B. Hillman, treasurer of AREA; retired chief engineer, Chicago & Western Indiana Railroad and Belt Railway of Chicago.

Mr. A. V. Johnston, director of AREA; chief engineer, Canadian National Railways, Montreal, Que.

Mr. W. H. Hobbs, director of AREA; chief engineer, Missouri Pacific Railroad, St. Louis, Mo.

Mr. C. J. Henry, director of AREA; chief engineer, Pennsylvania Railroad, Philadelphia, Pa.

Mr. J. C. Jacobs, director of AREA; engineer maintenance of way, Illinois Central Railroad, Chicago.

Mr. W. W. Hay, director of AREA; professor of railway civil engineering, University of Illinois, Urbana, Ill.

Mr. W. M. Jaekle, director of AREA; chief engineer, Southern Pacific Company, San Francisco, Calif.

Mr. T. F. Burris, director of AREA; chief engineer system, Chesapeake & Ohio Railway, Huntington, W. Va.

Mr. T. M. von Sprecken, director of AREA; assistant to chief engineer, Southern Railway System, Washington, D. C.

Mr. W. E. Cornell, director of AREA; engineer of track, New York, Chicago & St. Louis Railway, Cleveland, Ohio.

Mr. F. L. Etchison, director of AREA; chief engineer, Western Maryland Railway, Baltimore, Md.

Mr. W. J. Cruse, director of AREA; engineer maintenance of way, Great Northern Railway, St. Paul, Minn.

Now you may applaud. [Applause]

In making the introductions thus far, you may have noticed that I skipped three special guests at our speaker's table. This was done purposely because a little later in our program this morning I expect to present these men to you and permit them to bring us a few words of greetings from their respective organizations.

The first item of business on our program is approval of the minutes of our 1959 Annual Meeting, which were published in Vol. 60 of the AREA Proceedings, a copy of which was furnished to each member. Spread out as they are over 212 pages in the Proceedings, it is obviously impossible to read these minutes here, but, assuming that many of you have read them, I will entertain a motion that the minutes be approved.

[Motion was duly made and seconded, was put to a vote, and carried.]

Address of President Frank R. Woolford

Greetings—and thanks to our membership for a most successful year. I am certain all of us have benefited tremendously from the activities of our 23 hard-working committees, together with the loyal and untiring support given our committees by Vice President–Research W. M. Keller, and by Director of Engineering Research Gerald Magee and his most efficient technical staff.

I wonder if you, our general membership, ever stop to realize the tremendous effort required to direct the extensive activities of our committees, to publish our bi-monthly news letter and bulletins containing the periodic reports of committees relating the results of their studies, and to plan our annual convention activities and arrangements. The planning and programming of our Association's activities would appear to be automatic, but actually they are the result of the untiring efforts of our most conscientious and industrious executive secretary and his proficient and loyal office staff. They are always at your service, anxious to assist any member, committee, or even an outsider in search of information about our American railroads or railroad engineering in general. They even willingly take time to answer many of the questions which your president should know or should have known before taking over the reins of the Association. To be honest about it, there are many, many things about which I am uninformed, and I must rely on them for the answers.

Also, your Arrangements Committee under the able direction of Sam Johnson and his hard-working and efficient staff, should be commended for a job well done. I have patted myself on the back numerous times for having had the foresight of selecting

such an expert as Sam Johnson and persuading him to join me in this year's planning. I am certain all of you will agree when you experience what transpires in the next 2½ days. Come Wednesday afternoon, I am confident you will stop and look back with appreciation on the success of our Arrangements Committee's efforts during the past year in setting up the facilities for giving you the annual summary of the research and development activities as accomplished by our technical committees.

When you selected me as your junior vice president some three years ago, I must admit I pondered at length as to whether one located where I am—at the furthermost western point just short of the Pacific Ocean—could satisfactorily serve your Association, headquartered in Chicago and having its majority membership in the Midwest and East. Only after receiving my president's approval did I accept your gracious offer. (Incidentally, he will say a few words to us tomorrow.) I hope you have not regretted your selection, nor will not after reviewing this year's accomplishments as will be reported during the next several days.

I must admit I never fully appreciated the extent of our committee's activities, the productive and untiring work done by committee members and the enthusiasm of our committee membership until I had the opportunity of meeting with them and participating in work sessions of each of the various committees. Gentlemen, you who have not availed yourselves of membership and actual work with one of our committees and participated in their activities, have never really felt that excellent feeling that is unique to our Association and comes only from actual committee work participation. I would recommend that you participate in committee work if you have not already done so, and see if you do not obtain the pleasing effect that I have experienced. Our work committees are the backbone of our entire Association. For continuing success, we need full membership participation in our committee work assignments to retain the top position our Association enjoys in the transportation engineering field today. Our Association will rise or fall according to the effectiveness of our research and development activities. We must continue to advance. I ask your continued assistance.

Statistically, the past year has been a good one for our Association, regardless of the trying times our properties have experienced. With the many interruptions in our industrial activities because of labor differences, strife and general political unrest, our membership has continued to increase, reaching a total of 3373 as of February 1st this year, a net gain of 63 over the membership on the same date in 1959. Actually, I would hazard a guess that the total is considerably greater today, considering the applications that have been approved through February and thus far in March. To me, this indicates a healthy condition, as it indicates acceptance of our Association's accomplishments by the young engineers on our American rail transportation properties today.

After listening to the discussions of our membership in general and reviewing exchanges of correspondence, I am anticipating an unanswered question which I think is on the tip of the tongue of many of you. I am going to try and outguess you by raising the question now: namely, why the reduction and, in some instances the entire elimination, of funds requested by our work committees for the furtherance of technical investigation, study and research during 1960?

I hope no one will lose faith or that wonderful enthusiasm for the advancement of our studies on account of the refusal of the Association of American Railroads to grant the research budget requested by you for 1960. Your Board Committee on Research, together with your executive secretary, Messrs. Magee and Keller, as well as your president, met with an appointed AAR special Board Committee investigating AAR—AREA research costs and activities, and with this AAR committee we reviewed our

past, present, and future research program and research budget requests. From this joint meeting, we found misunderstanding and the use of improper terminology in presenting our AREA budget requests. Also, a lack of a proper description of assistance desired by our committees and a similar lack of details of the savings to accrue as justification for expenditure were found to exist in the minds of this special AAR Board Committee. I would assume that a similar lack of understanding exists among others on the Board of Direction of the AAR, especially those not members of the AREA and not familiar with our committee activities or their productivity.

This omission of a clear description of the items in our annual budget request and detailed justification therefor is not unusual among engineers, as too often we are far too brief in explaining and justifying proposed projects to others not familiar with them. This will be corrected in our future requests by a proper separation of the request for funds as to actual use intended, such as for technical assistance to committees or for applied or basic research (whichever is applicable to a committee's subject). Also, each request will be accompanied by a detailed statement of the monetary savings or other benefits expected to accrue from the funds requested. Certainly if our supporting properties are shown the tremendous savings realized through our committee study activities in the past, and the potential savings in manpower. materials, and methods possible in the future from the small monetary assistance requested, adequate funds will be provided.

Such funds were not appropriated in 1960. In this regard, perhaps I, as your president, and your Board of Direction are to be criticized for neglecting to apprise you of the additional descriptive data and the supplementary justification needed to properly place your request before Mr. Keller for his subsequent presentation to the AAR Board for consideration. I am hopeful that this will be done in 1960 in connection with our 1961 budget requests in order that necessary funds will be made available for the continuation of your committee activities. Each of you, and especially committee members, can assist your Board of Direction in favorably presenting this request by making the managements of your respective properties familiar with the tremendous benefits we have realized and what additional benefits we stand to realize in the future by the AAR's continued support of the worthwhile and productive activities pursued by our committees.

In his address to you a year ago, Mr. Meyers reviewed one subject which has been foremost in my mind during the past many years and one which I have made dominant during my term as your president. This subject is the convention's theme this year—actively interwoven throughout our convention discussions—and will be discussed from this podium today by a selected panel. I make reference to standardization of materials used in the construction and maintenance of our rail properties today. I have highlighted this subject in my numerous discussions with our work committees, have covered the subject during my addresses before various associated groups during the year, and have publicized standardization through our AREA News. Really, the subject is not new, it is only a further step ahead in efficiently carrying out the construction and maintenance activities on our rail transportation systems. This development began many years ago under the guise of technology. Later on. our effort took the path of mechanization, and now with this development well on its way to accomplishment, our next forward step is for standardization of all materials used in construction and maintenance.

Standardization is not a new subject to this group. Many years ago the Association had a standing committee on standardization which actively progressed various phases of this subject over a period of several years. Committee 4—Rail, is actively progressing such a study at this time as applicable to rail sections. Committee 5—Track, has been

actively progressing such a study for several years as concerns trackwork plans. One group of carriers in the St. Louis area, commonly known as the Southwestern group, has agreed upon a set of standard plans applicable to track turnouts and several of the accessory groups of track fastenings. I understand the majority of the carriers in the Southwestern group are adhering to this agreed-upon segment of standardization. A second group, operating in the Western section of our country, has adopted a standardization plan involving main-track rail sections, turnouts, and track accessories, designating their agreement as Western standards.

My interest in this matter during my term as your president has been in an endeavor to further accelerate group acceptance of standards, hoping for an expansion of such planning beyond rail and track turnouts, to include all materials involved in our construction and maintenance activities—the final objective being national acceptance. I can think of no better way of controlling the ever-increasing costs of materials in our construction and maintenance activities than by a rapid joint development of standardization, accepted first on an area basis, then on a nationwide basis. When national acceptance of standardization materializes, and it will only be done through joint committee study with representatives of all carriers participating, economies badly needed in our construction and maintenance endeavors will certainly become a reality. Other industries have accepted standardization of materials and have found it to be practical, economical, and highly desirable as a further aid in continuing a profitable existence. Our American rail properties are no different and can benefit in a like manner. I am approaching the end of my term at the helm of our Association, and in doing so, I only ask that you continue your efforts in this regard to the end that a satisfactory standardization plan will be accepted by all properties.

In conclusion, I would indeed feel remiss if I neglected to express my appreciation for the assistance given to our Association by our ladies who are seated in the balcony. Were it not for their guidance and assistance in directing our actions, I am afraid we would soon find ourselves taking a blind-alley approach. I, for one, can speak from experience, as the support given to me by my counterpart, who is at this time assisting from the balcony, has been truly inspiring and has served as my guiding light.

Thanks are in order, also, for our 23 committees for their loyal assistance and productive accomplishments; and last, but certainly not least, thanks to Mr. and Mrs. Neal Howard for their untiring efforts and loyal support in bridging the gap between San Francisco and Chicago.

I want to express to all of you my sincere appreciation for your electing me as your pilot during the past year. I consider it a rare privilege to have had the opportunity to serve as your president and to direct our Association's activities. It is an honor and recognition which I shall cherish forever. I have benefited tremendously from the experience and can only humbly say that in stepping down, I am a wiser and much more understanding person. I sincerely hope that my tenure has been equally as gratifying to you.

Thank you for your attention. [Applause]

President Woolford: As you all know, this Association has a most efficient executive secretary, and the next order of business is to hear his report. Mr. Howard, I shall be pleased if you will present your report at this time.

Executive Secretary's Report

Mr. President, past and present officers, members and guests:

Mr. Woolford, I appreciate your overly generous comments in behalf of the secre-

tary and his staff, and I particularly appreciate Reverend Allen's remembering those who helped participate in planning this convention and his request for continued guidance for those who must continue to help with this convention. We need all the help we can get. Thank you, Reverend Allen.

The complete text of the Secretary's Report appears in the March Year Book Bulletin of the Association, which was mailed to all members on March 8 and 9. Many of you have, no doubt, received your copies. It would obviously be inappropriate, even if time permitted, to read here any appreciable part of this 18-page report. Therefore, and especially in view of the exceptionally full program still ahead of us this morning, I will, with your permission, limit my comments to the minimum in order to give the time to our speakers.

But you should know, and I want to confirm what President Woolford has told you, that the Association had in 1959 another good year in every respect, and a significant year in some respects. Right from the beginning of the year there was a sense of release from some of the psychological and real restrictions which prevailed throughout most of 1958. Things were given a big boost by our very successful 1959 convention, and, encouraged by our president and our Board of Direction, our committees have been on a near full production basis. This has, no doubt, been evident to you as you have received and read the AREA report Bulletins for the past four months, and it will be further evident to you as the program of this convention unfolds.

In our Association, we don't measure our success by number of members, although to the extent that our membership figures show sustained or increased interest in the Association and its work, they are a measure of success. Therefore, it is noteworthy that membership in the Association rose to an all-time high of 3373 in 1959—a net gain of 63 over the previous year—continuing the uninterrupted growth in membership each year for the past 16 years, with the single exception of 1958. Significant, too, for the first time in seven years, there was an increase—an increase of 15—in the number of our Junior Members—to a total of 101.

Most of those who joined the Association during 1959—as in the past—did so on their own initiative or on the suggestion or encouragement of present members, but it must be said that the favorable growth of the Association during the past year was influenced to a considerable extent by the special effort of the chief engineering and maintenance officers of a few roads to encourage membership among the qualified non-members of their organization, including the younger technical men who had been taken on in recent years.

And, gentlemen, continued interest on your part in this regard is certain to be one of the most important influences in maintaining the membership of our Association, and thus reflect back on your various railroads the benefits to be derived from membership. So I hope you will keep this in mind and that you will see that qualified men on your properties, including your newer, more promising young men, are invited and encouraged to join our Association.

The record of committee activity during the year shows there were 1128 members serving in 1248 places on committees, but as President Woolford has told you—"Yet there is room." The record also shows that committees held a total of 73 meetings; and that they produced one or more reports on 120 of their 195 assignments.

The Board again attempted to keep in close touch with the work of committees, to encourage their efforts, and to assist where possible by having an officer or director of the Association sit in, as a guest, on at least one meeting of each committee during the year, with a pre-arranged opportunity for him to present the thinking of the Board on current Association matters and to receive suggestions from the committees. Your

president took a special interest in this, and even though no committee meetings were held west of Colorado Springs, Colo., and in spite of the long travel distances involved for him, he, personally, attended one or more of the meetings of 22 of the Association's 23 standing and special committees—including meetings as far east and south as Montreal, Washington, D. C., Atlanta, Ga., and New Orleans. It would be difficult to overestimate the encouragement which this gave to committees in their work.

There are many other aspects of Association activities which I could discuss with you here, such as the broad scope of the work of our committees; the alertness of our committees to take on new subjects to keep abreast of developments; their keen interest in research and test activities; and the extensive and widespread distribution of Association publications, but I shall refrain from doing so, both because all of these matters are covered in some detail in the Secretary's Report, and in the interest of saving time this morning.

In summary, one thing is certain about the AREA on the basis of its record, and that is, with any shortcomings which it may have, it continues a powerful influence for the good in the railroad industry. Its officers, directors and members, with the encouragement of their managements, have made it so. With a continuation of such, I am confident that the Association will move forward into still higher ground in the years ahead.

Now, in a final word, I want to thank all of you—President Woolford, and other officers and directors, our committee chairmen and many of you members for your splendid cooperation with the secretary's office during the past year. It has been a pleasure and a privilege to work with you—and a real challenge to try to keep up with you—and we in the secretary's office look forward to the unfolding of the tasks and opportunities in the year ahead.

Thank you. [Applause]

President Woolford: Thank you, Mr. Howard. I am sure our members are pleased to hear you report that the Association has had a most favorable year in every respect. I want to thank all of those who had a part in bringing this about, our officers and directors, our committee chairmen and members, our secretary and his staff, and all those who have collaborated with our Association in any way.

Viewing the workings of our Association from the special vantage point which I have had for the past year, I have been more impressed than ever before with the character and extent of the responsibilities of your officers and directors, and with the work of our committees. If we all continue the same interest and effort in the year ahead, I am sure our secretary will have an equally favorable or more favorable report to make to you a year from now.

As your time permits, I hope many of you will read the secretary's report as it appears in the March Year-Book Bulletin.

Our next order of business is the report of our treasurer, Mr. A. B. Hillman, retired chief engineer of the Chicago & Western Indiana and Belt Railway of Chicago. Mr. Hillman, we will be pleased to receive your report.

Treasurer's Report

Mr. President, members, and guests:

I am pleased to be able to tell you that, despite anticipation of a deficit year for the Association in 1959 as the result of generally rising costs on the one hand, and closely circumscribed income on the other, the Association closed the year "in the

black"—not very black, but still black. This favorable situation is set forth in detail in the Annual Report of your Treasurer, the Financial Statement, General Balance Sheet, and Statement of Cash Receipts and Disbursements for the calendar year 1959 as they appear in the March Bulletin of the Association. These same documents do show, however, that the total assets of the Association as of the end of the year were some $2,000 lower, compared with 1958—something not to be overlooked.

I shall not attempt to detail the Receipts and Disbursements during the year, except to say that overall, Receipts, which amounted to $80,407.16, while lower than in 1958, were somewhat higher than anticipated, and that Disbursements as a whole—$80,297.48—were somewhat lower than had been expected, thanks to judicious management, efficient operation, and to certain contemplated expenditures which did not materialize. The result was an excess of Receipts over Expenditures of $109.68 for the year.

In this connection, I would like to add just a word to our secretary's comment about membership—but from a different angle. As you no doubt realize, considerably more than 50 percent of the income of our Association is derived from membership dues and the entrance fees paid by new members. Without this income at its present level, the Association would find it necessary to curtail its activities and services. On the other hand, to the extent that this source of income may exceed the present level through increased membership, our Association can expand its activities and services. Thus it is seen, from a financial standpoint, the importance of maintaining, or even increasing the membership of the Association, as was done during 1959.

Looking ahead to the current year, it is anticipated that the 1960 Financial Statement will, of necessity, show an excess of Disbursements over Receipts of some $8,000 to $9,000. This should be no cause for alarm, however, since contemplated expenditures in 1960 will increase the publications inventory of the Association—in Manuals and Trackwork Portfolios—by some $7,000—resulting in an actual contemplated deficit of only $1,000 to $2,000 in 1960.

Thus, the Association ended the year 1959 in a sound financial condition, a condition which I feel we can confidently expect to prevail in 1960 and for the foreseeable future with a continuing membership at least at its present level; the holding of expenditures for special, non-remunerative activities and services within practical limits; the continued exercise of prudence and economy in all necessary expenditures; and a continuation, and extension if necessary, of the policy of making adequate "user charges" for all services afforded non-members and for special services rendered individual members or groups of members.

Thank you. [Applause]

President Woolford: Thank you, Mr. Hillman. We greatly appreciate your continued valuable service to the Association as its treasurer. It is highly gratifying to all of us that you have been able to report ending the Association year in the black, small as those black figures are. That is quite an achievement in these days of continually rising costs and the continuing efforts of our Association to be of the greatest possible service to its members and the railroads.

I am sure we are all in accord with your admonitions regarding carefully controlled expenditures and the greatest possible efficiency in our operations in the year ahead. Thank you again, Mr. Hillman, for your report.

Gentlemen, you have heard the reports of our secretary and our treasurer. A motion is in order that these reports be accepted. Do I hear such a motion?

[Motion was regularly made and seconded, was put to a vote, and carried].

Greetings from the Signal and Electrical Sections, AAR

President Woolford: We are pleased to have at our speaker's table this morning representatives of the Signal and Electrical Sections of the Association of American Railroads, which, with the AREA in its capacity as the Construction and Maintenance Section, make up the Engineering Division of that Association. These men are the chairmen of their respective sections, and I would like to recognize them at this time and give them an opportunity to bring us a few words of greetings if they would care to do so. First, may I present Mr. V. O. Smeltzer, superintendent of signals, system, Atchison, Topeka & Santa Fe Railway, chairman of the Signal Section. Mr. Smeltzer.

V. O. Smeltzer: President Woolford, officers, guests, and fellow members of the American Railway Engineering Association:

It is a real pleasure to me to bring you greetings from your brother engineers in the Signal Section.

Your president made a trip to Washington, D. C., last October to address the Signal Section assembled in our Sixtieth Annual Meeting. This cooperation between our organizations we in the Signal Section deeply appreciate. We need to exchange ideas and to learn more about each other's problems, especially with respect to track structures.

Our signaling problems are your problems in many ways. You are well aware of this, since on many railroads the signal engineer reports to the chief engineer.

I should like to take a few minutes to discuss some of these problems with you.

The very heart of our signal systems is the track circuit. It consists of some form of electrical energy applied to the rails and detected by an electromagnetic device called a relay. Actually this is a very simple form of electrical circuit. The problems begin to arise when we attempt to apply it to the track.

Obviously, batteries and relays cannot be on or in the track structure, so we must house them in relay cases and battery boxes away from the rails. Connection from the battery and relay to the rails must then be made by means of wires. These wires would not last very long lying loose on the fill and ballast, so they are buried for protection.

Many of you will recall the old pump log or trunking used for this purpose a few years ago. More likely you will remember the trenches dug through the track ballast to bury this trunking some 18 in below the base of rail, and the soft spots this practice left in the track. A wooden riser was used next to the rail to allow the buried wires to be connected to the rail.

Later, cables were developed with tough outer covering allowing us to eliminate the wooden trunking. However, risers or bootlegs, now made of metal, were still required to bring the wires up at the side of the rail for connection to the rail.

With the advent of mechanized track equipment, such as ballast tampers, scarifiers, plows, and the like, the signal bootleg becomes a problem. Its location conflicts with the use of much of this equipment. Removing it entirely while track work is performed is expensive and in many cases would require taking signals out of service. You know how the operating people would react to that.

This is one of our problems today. Perhaps a relocation of the track connection is what is needed. The Signal Section has published several proposals along this line, none of which seems to be the complete answer. We are all working on it. We need your assistance. The more ideas, the sooner we will arrive at a satisfactory solution.

To return to the track circuit itself, we cannot let the electrical energy required "run wild" down the rail but must confine it within definite limits. This is done with insulated joints.

At best, these insulated joints require a lot of maintenance. We have tolerated them in their present familiar form, with fiber insulation and its limited life, because that is all we had. The track structure is hard to maintain around insulated joints. With the advent of welded rail, our maintenance troubles increased.

Solution to the joint problem is now being actively attacked on several fronts. New synthetic insulations are under test, and some of these offer hope for the future. The AAR Research Center is working on a solution that may prove to be the answer.

Electronic track circuits without the use of insulated joints are being tried for the control of highway crossing protection and release of electric switch locks. These appear to be of value for these specialized services but have not as yet been developed to the point where they can be used to replace conventional track circuits for general signaling.

Another problem of close mutual interest to our two engineering groups is the location of interlocked switches, whether this be on new railroad or in yard rearrangement. Two of the primary requirements in selecting a switch location are, first, the function the switch is to serve, such as end of siding, yard lead, crossover, etc., and second, suitable topography for the track structure required. To these I would add an item of equal importance, namely, the location for signals governing movements over the interlocked switch.

In addition to suitable topography for signal structures, view is of paramount importance. The crew on an approaching train must be able to see the signal in order that they may make proper response to its indication.

We are all well aware that the signal engineer in spacing signals where interlocking is not involved does not select locations solely on the assumption that they can be seen for a specific distance but rather endeavors to space them at least stopping distance from the next signal. In interlocking, however, signals must be in close proximity to the interlocked switch they protect. Where proper signal spacing cannot be provided, suitable restrictive signal indications must be used, resulting in slower train movement.

I have mentioned some of our mutual problems. There are, of course, others that directly involve you men in railroad engineering. With your assistance, solutions will be found.

In closing I want to extend to you a cordial invitation to attend the Annual Meeting of the Signal Section to be held in the Morrison Hotel, Chicago, October 11–13.

Thank you, Mr. President, for allowing me the privilege and honor of addressing our Association. [Applause]

President Woolford: Thank you Mr. Smeltzer. We have long had pleasant and cordial relations with your Section and its various committees, and we are sure such will continue in the future to the mutual advantage of both of our groups and the railroads. We appreciate your being with us this morning and your kind words of greetings. I hope you will convey our best wishes to the members of your Section. I think I can assure you that you will have a good participation from this Association in your annual convention this Fall.

I would now like to present to you the Chairman of the Electrical Section of the Association of American Railroads, Mr. J. J. Schmidt, electrical research engineer of the Denver & Rio Grande Western Railroad. Mr. Schmidt, we are likewise highly pleased to have you with us and would appreciate any words of greetings which you might wish to bring from your Section. Mr. Schmidt.

J. J. Schmidt: Mr. Woolford, ladies and gentlemen of the American Railway Engineering Association:

It is with great pleasure that I bring you greetings from the Electrical Section of

the Association of American Railroads. We in our Section are very, very proud of our continuing association with AREA and also of the fact that we do function as the Electrical Section of the Engineering Division.

I should like to remind you of the areas in which we try to be of service to your organization in our specialty. You will remember we have Committee 3 covering air conditioning of buildings; our Committee 5 on illumination covers lighting of railroad yards, shops and buildings; our Committee 6 is a very excellent committee covering electric welding. Committee 8 on power supply goes into the distribution of electric energy in the railroad yards and terminals. Committee 10 on wire and cable covers specifications for wires used throughout the entire railway industry. Committee 11, which is cooperating with your Committee 6, covers electric heating. Their report this year, by the way, will have an extremely interesting review of the economics of heating a signal tower building by electrical means. Our committee on shop facilities for locomotives also cooperates with AREA Committee 6. And finally, our Committee 15—Relations with Public Utilities, cooperates with AREA Committee 20.

I might add that the chairman of our Committee 15 and the chairman of your Committee 20 are one and the same man, Mr. Ed. Hastings of the Chesapeake & Ohio Railway. I am sure you will agree that this is the height of efficient collaboration.

The work of our committees will be presented and discussed from the floor at our annual meeting in San Francisco on June 14, 15 and 16 of this year. These reports will also be found in the 1960 Advance Reports of the Electrical Section, and copies are in the hands of the electrical engineers on your railroads. I earnestly invite and solicit your active participation in and support of our 1960 meeting. And again, Mr. President, we wish you a very, very successful 59th Annual Meeting of the American Railway Engineering Association. [Applause]

President Woolford: Thank you, Mr. Schmidt. We are glad that you could be with us here today and we appreciate your words of greeting. I hope you will, in turn, convey our kindest regards to the members of your Section.

Speaking of where your next annual meeting will be held, I can't help but say that your group has certainly selected the choicest spot in the United States for such a meeting. I know it will be successful and I would echo your invitation to come out and see the West. It is a wonderful country.

Both the Signal and the Electrical Sections, like our own Association, are fortunate in having very capable secretaries. I refer to Bob Balliet, secretary of the Signal Section, and Carl Elber, secretary of the Electrical Section. If Mr. Balliet is in the audience, I would appreciate his standing and being recognized. [Applause]

If Mr. Elber is present, may I ask that he please stand and take a bow. I don't see him, gentlemen, so he probably wasn't able to attend today.

Greetings from the National Railway Appliances Association

President Woolford: It is also highly appropriate that we have at our speaker's table and duly recognize the president of the National Railway Appliances Association, even though this is not an exhibit year of that Association. The current president of the NRAA is Mr. J. B. Templeton, president of Templeton, Kenly & Company, who is known to most of us as "Jack—The Jack Man." I would like to recognize him at this time and give him an opportunity to say anything that is on his mind. Mr. Templeton.

J. B. Templeton: It is my privilege to appear before you as the representative of the National Railway Appliances Association. Our members enjoy the close and

cordial relations that exist between our Associations. It is a real privilege to be affiliated with you and to have a share in your activities toward the improvement of our fine railroad systems.

In this non-exhibit year the attention of the National Railway Appliances Association is focused on the exhibition to be held in March 1961 coincident with the AREA convention.

This is destined to be an exhibition of historical importance. There are several reasons that lead me to make this statement. One is the fact that our member companies, practically without exception, are engaged in strenuous efforts to develop new and improved equipment, devices and materials designed to help reduce railroad maintenance costs. Another reason why I believe our next exhibition will be outstanding is the very strong possibility it will be staged in the new $34 million Exposition Center now under construction on Chicago's lake front.

The size and scope of this new center are not easy to describe or imagine. The main exhibition hall, for example, will cover an area of 310,000 sq ft. It will provide ample space and an ideal setting for our exhibitions.

My enthusiasm for the Exposition Center leads me to point out that it will offer modern and complete facilities for holding meetings. Adjacent will be plenty of public and private dining space, with full banquet service for groups up to 5,000, all connected by frequent bus service with "loop" hotels only 2½ miles away.

On behalf of all the members of the National Railway Appliances Association, congratulations and best wishes for the success of your 59th Annual Convention and thank you for this recognition. [Applause]

President Woolford: Thank you, Jack. We appreciate your greetings and consider ourselves fortunate in the close and friendly relations which we have with your group. We are glad so many representatives of your member companies are here at our convention, and we look forward with anticipation to the exhibit which your Association plans in connection with our 1961 convention.

At this point I want to thank all those who have honored us by their presence at our speaker's table thus far this morning and, with the exception of Vice Presidents Brown and Beeder, I would like to excuse them in order that we might honor others in connection with following features of our program. I am sure you gentlemen will enjoy the remainder of our morning program equally as well in the audience and may even find that more advantageous and comfortable.

Gentlemen, as most of you are aware, the special guests whom I have invited to our speaker's table are all officers of the Association of American Railroads. I would like to present these men to you at this time.

First, Mr. D. P. Loomis, president of the Association of American Railroads, who, you will recall, was the keynote speaker at our 1959 convention.

Next, I would like to present Mr. W. M. Keller, vice president, Research Department, of the Association of American Railroads, who likewise has been a speaker on one of our previous programs.

The man I will now present to you is the keynote speaker of this convention. As the vice president, Operations and Maintenance Department, Association of American Railroads, effective August 10, 1959, this is the first time he has appeared on one of our programs, but we welcome him here this morning. I refer to Mr. Curtis D. Buford.

Mr. Buford is neither a stranger to us or our Association. He is an engineer by training and has been a member of the American Railway Engineering Association since

1955. He was graduated from Massachusetts Institute of Technology in 1942 and shortly thereafter entered the Corps of Engineers, U. S. Army, as second lieutenant. In about six months' time he became connected with the Military Railway Service, with headquarters at St. Paul, Minn. Fol'owing that, he served in various military railway units in the United States, Alaska, and Europe, and while in Europe was attached to the Second Military Railway Service headquarters under General Burpee. During that time, he became a captain and was advanced to the grade of major on termination of his military service.

Mr. Buford entered civilian railroad service in 1946 in the transportation department of the New York Central System. In that department he held successively the positions of trainmaster, assistant superintendent of freight transportation, division superintendent, and then assistant general manager of the road's Western District at Cleveland, Ohio, where he was located when he was called into the service of the Association of American Railroads, succeeding the late R. G. May, who was admired and respected by all.

In assuming his position with the Association of American Railroads, I am sure many of you know that he followed in the footsteps of his father, Charles H. Buford, who was vice president, Operations and Maintenance Department. AAR, from 1939 to 1946, and subsequently president of the Chicago, Milwaukee, St. Paul & Pacific Railroad. Like Curtis, his father, now in retirement, continues to be a member of he AREA, as does also his brother, Jack, who is vice president of the Hanna Coal & Ore Company at Cleve'and. It is an honor and pleasure for us to have these three Bufords on our membership roster.

As vice president, Operations and Maintenance Department, I am sure you know that Mr. Buford heads the largest single department in the Association of American Railroads, of which the American Railway Engineering Association is a part. We are especially pleased to welcome him to our convention and to our speaker's table and I want to present him to you now. He will address us on the subject, "Main Lines Toward Better Railroads." Mr. Buford. [Applause as all stand]

Main Lines Toward Better Railroads

By C. D. Buford

Vice President, Operations and Maintenance Department
Association of American Railroads

President Woolford, distinguished guests, officers and fellow members of the AREA, ladies and gentlemen:

It is truly an honor to be here today, because I feel I am speaking to a group that has tremendous opportunity to strengthen the future of our industry. You engineers have had great responsibility for past railroad progress. The sweeping advances in technology which we are now experiencing provide a challenging opportunity for you to develop and adapt new ideas for the improvement of railroad operations.

This AREA meeting provides a two-fold benefit: First, industry benefits from your combined practical knowledge of railroad operations and maintenance activities. Secondly, you benefit not only by bringing home new ideas to your properties but also by learning how to adapt solutions to your local problems which will fit in with a strengthened national railroad capability.

Railroad engineers today must be knowledgeable about many phases of railroading which perhaps previously were more of a specialized nature. Certainly railroad engineers

today must be knowledgeable about the transportation picture and in particular about modern railroad transportation techniques. They must understand legislative issues on the national level as well as on the local and regional level, and, in addition, must recognize action which they can take and carry out in order to help bring about changes in regulatory policies so necessary to permit a growth and development of efficient railroad transportation. Engineers more than ever before must know about new research developments and be capable of applying these new ideas to railroad operations and maintenance.

Recognizing your interest in transportation I would like to say a word about the business outlook for the next several months. Estimates of manufacturer's output for the year have been reduced several times in recent weeks. Automobile production is down from 7 million to an estimated 6,250,000. Steel production estimates have dropped from 130 million tons to about 120 million tons.

However, if automobile production does reach 6,250,000, it would still be the third best year in history. And steel at 120 million tons would be a new high in the history of steel production. Consequently, we can still be optimistic about the second quarter of 1960 despite disappointing carloadings during the past four weeks which have been adversely affected by weather conditions.

As you may know, the total freight-car fleet of the nation's railroads has been decreasing steadily for some time account retirements exceeding installations of new equipment. On the first of February we had 17,000 less cars than we had a year ago. Increased utilization of existing cars will enable us to take care of the increased traffic, but the success or failure of that effort will depend on our ability to reduce detention on all freight equipment loaded or empty by railroads as well as shippers and consignees.

Freight cars are in the hands of shippers and receivers about one-half the time. Through the great cooperation of the 13 Regional Shippers Advisory Boards we are jointly continuing a campaign to have cars unloaded within allowable free time and to have unloaded cars turned back to the railroads free of rubbish, debris, strapping, etc., thus eliminating the necessity of cleaning-track movements. The responsibility, however, of conserving the serviceable fleet and reducing turn-around time is ours. Many of you here today can be helpful in the campaign to increase freight car efficiency, especially by allowing only essential use of box, hopper and gondola cars.

Ownership of hopper cars has been reduced by approximately 27,000 cars in the last year, and this type of equipment will be our number one problem in the next 90 days. An early opening of the Great Lakes this year; movement of ore now in ground storage, and the movement of coal to the Lakes will pick up along with the resumption of construction work, so that every serviceable hopper car will be needed. Those of you who have under your control hopper carloads of ballast, cinders and other similar construction material should redouble efforts to bring about unloading and quick release of these cars as promptly as possible—of course, making much effort to have such materials loaded in non-revenue cars in the first instance.

Along with a high production of steel, we may expect gondola cars to be in heavy demand. The difficulty here is with special types of gondolas and in that connection I urge that you pay special attention to 61- to 65-ft gondolas, seeing to it that such long gondolas are not loaded with ties, sand, and other bulk commodities. Sixty-five foot gondolas are expected to be in tight demand to protect the movement of structural steel.

Special types of box cars have been continually short even during the recent box car surplus period. Double-door 40-ft cars and 50-ft cars of all types are now short

and will continue to be short despite railroad installation of some 55,000 of these cars in the last four years. You can be helpful by confining the loading of company material to a lower-grade box car. Should special types of box cars arrive with material which could have been loaded in an ordinary box car, effort should be made by your people to eliminate further improper use of seriously needed equipment.

I would like to turn now to some of the national transportation policies where your help can be made extremely effective. Here briefly are some legislative reforms especially deserving of your attention and support:

Present tax policies effectively curtail our replacement and improvement programs, and will continue to do so until federal, state and local legislators recognize that exorbitant taxation of railroad property is killing the goose that lays the golden egg.

The federal government has assigned a totally unrealistic life span of 40 years to railroad property for tax depreciation purposes. This includes such perishable items as shop machines and freight cars, along with office buildings and other permanent structures. This average compares most unfavorably with the 5 years in which airplanes may depreciate and the 8 and 7 years, respectively, for heavy trucks and intercity buses.

Under such a system, our competitors can afford constant and timely replacement programs while railroads are tied to a cost recovery rate before taxes of a mere 2½ percent of investment funds per year. For example, consider a heavy steel bridge which cost $200,000 to build in 1913 carrying a suggested tax depreciation life of 50 years. Such a bridge would cost at least a million dollars to replace in today's market. Under present corporate tax laws, a railroad must earn about 1 and ¾ million dollars before taxes to attain the necessary $800,000 difference.

It would be well worthwhile to let your legislative representatives know that you support the railroad proposal calling for a maximum life span of 15 years for rolling stock and 20 years for other property for depreciation purposes. This proposal, if enacted into law, would free important sums of money with which to purchase the heavy equipment tools and facilities to conduct a railroad operation.

Another proposal in the field of taxation deserving your support is one that would allow railroads to set up so-called construction reserve funds out of pre-tax income. Money in such funds, if spent within 5 years for new capital facilities, would be temporarily exempt from taxes. This proposal would immediately make available large sums of cash for capital spending which would otherwise be paid out each year in taxes. It would constitute tax deferral—but not tax forgiveness.

Another beneficial aspect of the construction reserve plan is that it would tend to level out the extreme cyclical pattern in present railroad purchasing programs. Because of the natural lag between orders and deliveries, railroads often find themselves receiving and paying for cars in times of heavy car surplus—and awaiting delivery during rush periods of great demand. A leveling-out of railroad purchases also would be of tremendous benefit to the supply industry—with its hundreds of thousands of workers and their families.

Another tax matter you would do well to support is that of reciprocal tax relief by federal and state governments in their assessment of railroad property. Under such a system, whenever an enlightened state or local body grants a tax reduction to a railroad, the benefits thereof would not be whittled down by increased Federal taxation—which is the present fate of income not paid out in state or local taxes.

As for government regulation of transportation, what is needed is simply a policy of equal treatment for all and favoritism for none. For example, carriers should be given maximum freedom consistent with public interest to set freight rates and adjust

services in accordance with demand. Under such a policy, the public would be allowed to benefit from advantages inherent in each form of transportation—and uneconomic services which now bid up the overall cost of transportation could not long survive.

Extensive railroad research into transportation costs has given rise to new rate proposals substantially lower than competing rates—yet high enough to cover out-of-pocket costs. Included in these proposals are innovations such as guaranteed rates—a variety of agreed charges; incentive rates; contract rates; volume guaranteed rates; and multiple-car rates. These are intended to stimulate high-volume or constant traffic, and to regain and hold competitive business. They also would have the effect of reducing rail costs per ton and conserving car supply. Rates such as these are of great importance to shippers and railroads alike.

Government regulatory policies should require commercial users of public facilities such as highways, airways and waterways, to pay back in user charges amounts equivalent to the special advantages they derive from these facilities. The construction and maintenance from public funds of heavy-duty highways to accommodate "highway box-cars"; of airports and airway control centers, and of water facilities is out-and-out subsidy when not adequately repaid by the commercial beneficiaries—and discriminates heavily against the one carrier that pays its way all the way—the railroads.

It is particularly unjust, I think, for railroads to have to help keep their competitors in business through the payment of heavy and often exorbitant taxes. In this connection, you doubtless have heard of the classic—but far from unique—example recently provided by Toledo, Ohio. Taxes extracted by Toledo from its privately financed railroad station in a recent year were almost exactly equal to the deficit run up by its municipal airport in the same year.

Internally, railroad management and employes must unite in a real effort to cast off the bonds of antiquated work rules. Railroad employees must recognize the simple fact that out-of-date working practices have added over a half-billion dollars a year to railroad costs and are destroying jobs rather than making them. The sooner our industry can get rid of this indefensible waste, the sooner energies and resources can be devoted to improving service and facilities.

There are, of course, other problems facing the industry today that affect your work as engineers—problems that deal with the amount of money available for your activities. Among these are the legislative proposals that would add even more useless labor costs to the production of railroad transportation. I refer to the so-called track motor car bills, which under the guise of safety requirements would assign unneeded additional employees to self-propelled equipment such as track motor cars. Proponents of these bills have failed to prove their safety claims, and the fact is that safety would not be enhanced one iota by adoption of these proposals. Rather, new weight would be added to the already crushing featherbedding burden—and railroad efficiency would be cut back accordingly.

I would like to turn, now, to a brief consideration of problems directly affecting your work as engineers—and the challenges they present to you. No one in our industry is more aware than you of the changing nature of railroading as our industry keeps pace with the nation's expanding transportation requirements.

The present trend toward heavier car loads can be expected to continue unabated. This, in turn, makes increasingly critical the standards we set for everything from ballast beds to box car roofs. We must quickly develop more new procedures and break away from conventional maintenance methods wherever long-range economies can be expected.

For instance, studies that show us the effects of water on ballast and sub-soil also indicate that radical new measures are needed to reduce significantly the extra maintenance costs caused by water damage. One method of combating water effects already under study, as you know, is the laying of ballast in asphalt or heavy petroleum. The need was never greater to increase resistance of ballast and roadway to the effects of water and other factors such as vibration and pressure which promise to become more severe in the years ahead.

Crossties have undergone a quiet revolution in recent years. Modern methods of treatment and reinforcement have virtually doubled cross tie life. Current experiments with concrete and combination concrete and steel ties similar to those used in Europe look favorable. Forty years service life from concrete ties, reported by the French Railways, would be a significant improvement for American railroads to attain, although a difficult one because of our heavier wheel loads.

New mechanized methods of accomplishing work with track and structures have enabled considerable expansion of our maintenance of way dollar during a time of rising costs for labor and material. The role played in this effort by your committees has been and can increasingly be of great help to the industry.

Improvements to rail resulting from your work with manufacturing companies have greatly extended the useful life of this basic item. Aside from improvements in the metal itself, your ideas have given rise to new methods of laying rail which have made possible the smoothest ride in railroad history.

As a possible improvement over the welded and "frozen joint" methods, some progressive thinkers foresee the day when rails come out of mills in 1500-ft lengths, heat-treated as they emerge with automatically-controlled water spray, and thus save important sums of money now being spent in welding or joining our 39-ft lengths.

The use of welded steel bridge structures seems to be expanding. Other possibilities concerning bridge structures are the substitution of laminated wood in ordinary wood stringer and girder spans of up to 60 or 70 ft in length, and the use of prestressed concrete piling and beams or girders in replacement of wood trestles. Laminated wood girders are lower in first cost than steel, and do not require the maintenance expense involved in cleaning and painting. And in some localities, laminated wood might be economically preferred to prestressed concrete.

Also, additional ways of reducing the high cost of cleaning and painting steel bridges are worthy of investigation, for these structures will be with us for a long time to come.

Modern machines have transformed the old stationary road gangs into traveling groups of skilled machine operators, with only a minimum of unskilled manpower required. Yesterday's maintenance laborers have become today's machine operators—or have had the opportunity to increase their skill and earnings accordingly. Section gangs on one road now do a better job maintaining 50 miles of track than their counterparts 25 years ago were able to do with a 6-mile section.

And certainly, one of the dramatic changes which has taken place is the evolution of the modern automatic freight classification yard.

Indeed—there are many exciting challenges facing you in the next few years in your work of modernizing the plant and equipment of American railroads including actual acceptance and use of standard materials, parts and components in maintenance work. Already prefabricated construction has been implemented by manufacture of long rails either by welding of long lengths at manufacturing points or at central mechanized plants; prefabrication of industrial and yard track panels at central points and distribu-

tion as required to the using points; and prefabrication of turnouts such as is now involved in the construction of new automatic yards.

Future extension may include standardization and prefabrication of some reinforced concrete bridge components to cut the cost and time of erecting grade separations such as is now being done in Europe. And prefabrication of standard structural panels for buildings such as is being done in Russia on a large scale.

Many railroad structures could no doubt be standardized and designed for low-cost manufacture of components at central points, reducing the field job primarily to one of adequate foundation and assembly of components.

The trend toward transport coordination—best exemplified by the recent growth in piggyback and container traffic—will mean added engineering work in connection with team track installations and development of economical paving methods and materials. Development of low-cost snow removal methods also will assume an added importance, as well as the search for a truly universal container—one adaptable to all methods of transportation.

The expected near doubling of big-city populations, predicted within the next 40 years, could more than double our present commuter problem. This will continue to be an area of great growing challenge—to devise efficient low-cost facilities for the production of compensatory commuter services to be paid for by the people or the community so served.

In summary, let me again emphasize the immediate help that you and your associates may provide in improving the utilization of our existing freight car fleet during the expected favorable business period just ahead. Let me urge you to use your persuasive guidance at every possible opportunity to assist in securing a favorable legislative picture with regard to tax matters, user charges, transport diversification, and also in correcting violently improper regulatory trends such as the philosophy of the track motor car bill.

Further, let me urge you to redouble your efforts and to sharpen your ingenuity in developing railroad plant and improving maintenance techniques, taking advantage of the new aggressive research developments of our day.

In conclusion, I am sure we all agree that there is nothing more important to the efficient operation of a railroad than the morale and ability of its personnel. It is my feeling that the AREA has wielded a remarkable influence in providing improved training and bringing higher morale to railroad engineering people and that this effort has been an extremely valuable service to the entire railroad industry.

I wish you all success and achievement in your meetings this week. [Applause]

President Woolford: Thank you, Mr. Buford, for being with us this morning and for your stimulating and inspiring address. I know our committee chairmen who are in the audience will be very pleased to receive the information you gave them and with the cooperation that we know the AREA will get from you, being the one in charge of the Operations and Maintenance Department of the Association of American Railroads. You have outlined the problems that lie ahead for our industry and have helped us raise our sights, both individually and as an Association, as we seek to aid in the solution of these problems. I am sure you can count on us. We appreciate the compliments which you have paid our Association and especially the confidence you have expressed in us to carry forward the work of the Construction and Maintenance Section of the AAR.

We hope that you, along with Mr. Loomis and Mr. Keller, will remain at and participate in our convention to the fullest extent that your time will permit. Thank you again. If you prefer, you, Mr. Buford, Mr. Loomis and Mr. Keller may retire from the speaker's table.

Gentlemen, we now come to a feature of our program which, as I indicated in my earlier address to the convention, embraces a subject which is close to my heart. I refer to our Symposium on Standardization. I am sure that standardization in an overall sense appeals to all of you, but I am afraid that we in the engineering and maintenance departments of the railroads, if not all departments of the railroads, have largely given this matter lip service, have honored the pactice more in its breach than in its observance.

If this is true and, as a result, we are overlooking opportunities for greater efficiency and economy in our operations, we ought to know it. That is why we have scheduled this symposium on our program.

To participate in the symposium, we have selected four men who, from their different fields of responsibility, have given this matter a lot of thought and who are, therefore, particularly well qualified to discuss it with us. May I ask that these men please join me here at the speaker's table at this time.

As the first speaker in our Symposium on Standardization, I want to introduce to you Mr. Norman L. Mochel, manager of metallurgical engineering and consultant, Westinghouse Electric Corporation, Philadelphia, Pa.

Mr. Mochel is a native of Pittsburgh, and has spent his entire career with the Westinghouse Company, having been first employed in Pittsburgh in the Inspection Department of the Westinghouse Machine Co.

Mr. Mochel has an extensive record of professional and technical society activities and has received honors from many groups. In the American Society for Testing Materials, however, he has found the greatest outlet for his talents. After two terms on the Board of Directors—1935–1937 and 1949–1952—he was elected national vice president and subsequently president in 1954. He currently serves on five ASTM committees and was chairman of Committee A–1 on Steel for 14 years from 1939 to 1953. At various times he has served as secretary of other committees and as chairman of the Society's Standing Committee on Standards.

In addition to ASTM, Mr. Mochel is a member of the American Society of Mechanical Engineers, Society of Naval Engineers, American Society for Metals, American Welding Society, American Institute of Mining, Metallurgical and Petroleum Engineers, Iron and Steel Institute (England), the Institute of Metals (England), and the Franklin Institute. Time will not permit anywhere near a complete statement of our speaker's biography and many activities, but I do want to mention further that he has been the recipient of a number of society honor awards and has served the United States Government in many notable capacities, both in war and in peace.

From this brief summary of our first speaker's background, I am sure you will agree that he is especially and eminently qualified to participate in our symposium. Without further comment, therefore, I am pleased to present to you Mr. Norman L. Mochel, manager of metallurgical engineering and consultant, Westinghouse Electric Corporation, who will speak on "Standardization—A Tool to Greater Industrial Efficiency." Mr. Mochel.

Standardization—A Tool to Greater Industrial Efficiency

By Norman L. Mochel
Westinghouse Electric Corporation

It is indeed to me an honor that you have asked me, a person completely outside of your industry, to speak first at this, your 1960 Symposium on Standardization.

At the time of preparing these notes, I did not know in what manner I would be presented to you. I do not know exactly how a fish feels out of the water, but I am sure that the expression is intended to convey somewhat my present feelings.

My difficulty is that I am a past president of the American Society for Testing Materials, that I believe in the orderly work that it has done and is doing, and I cannot readily say "No" when Bob Painter, our executive secretary, asks me to do something in which ASTM is interested. And then when your good executive secretary, Neal Howard, gets together with Bob Painter—well, I am here before you.

Now, of course, I know many of you. In my many long years in ASTM and in Committee A–1 on Steel, I've learned of your great interest in the work being done; I have watched as your representatives have participated in so much of the ASTM activities; I have carefully reviewed the program for your meetings here this week, and it is so very obvious that there is much of common interest in your deliberations and needs, and in the work in ASTM.

I know how many of our great American railroads hold Sustaining Memberships in ASTM, and in that manner also show how they value the work of ASTM. Invariably, there is always a railroad man on our Board of Directors. As I recall, you have on at least four occasions been honored, and in turn honored ASTM, by supplying its president from your industry. And I am happy to say that my good friend R. W. Seniff, manager of research of the Baltimore & Ohio Railroad, is the nominee for vice president this year. So, we look ahead to another ASTM president from your field of interest.

In my years of work at the Steam Division of Westinghouse Electric, I can look back with considerable metallurgical satisfaction to at least seven most interesting experiences concerning important product developments for the railroads. But these experiences are long past. Today, my position before you may be stated most plainly, as follows:

(a) As a loyal citizen of this great nation, I know what the railroads have done to help make us great, and I know the important place you must maintain in the years ahead.

(b) I am a customer—at times your most loyal supporter—at other times your most bitter critic.

(c) The Seventh National Conference on Standards, of the American Standards Association, held in New York in 1956, used a most interesting slogan—"Standards Are Everybody's Business." We should all approve that statement.

It is most interesting to me that you should have a "Symposium on Standardization" on this first morning of your 59th Annual Meeting. I would have assumed that you would have become, through your 130 years of busy life in these United States, the most standardized industry of all. Your 1,700,000 freight cars, and your passenger and service cars must travel over all roads. Maintenance must be a problem, if there are not well arranged standards. You did adopt a standard gage of 4 ft 8½ in long ago. Service conditions certainly must vary depending upon geographical locations, but then again, they surely are much the same in most places.

But I recall that in my travels, by rail, over many of your roads, into practically every section of our country, I did see much that was different. And as I watch those

1.7 million freight cars go through my home town on two main roads, I do note that they appear to vary greatly in their general makeup and hardware.

And sometimes at nights, purely as a paying customer, it appears to me that some roomettes are a little shorter than others, and I wish for a standard of the greater length. And sometimes, I have the misfortune to be located near the end of a "standard" sleeping car or a newer vintage car, coupled together, and I complain bitterly that there appears to be something wrong with the alinement of the standard coupler.

About a year ago, our good friend Paul Garin of the Southern Pacific reported that he had recently had the opportunity to visit the research organizations of various European railroads, and was much impressed with the work of the Office for Research and Experiments of the International Union of Railways. During the past three years, I too have been privileged to ride the rails over France, Germany, Switzerland, Italy, Holland, Belgium, England, and Scotland. I have good friends in France who build large electric locomotives and other rail equipment. One sees much that is old and well worn, but there is much that is new and modern, with the need for and the evidence of much standardization. One is very early impressed with the standard of cleanliness and orderliness of the roadway, adjacent banks, and the like.

This word "standard" is a much used term—sincerely and seriously applied, often very glibly used, often abused, and apparently often misunderstood. The very idea of the word is something that is elevated, something to look up to, something to inspire one to further effort. And yet, there are many who do not like the word and that which is implied by it.

You can well imagine the part that standards play in a corporation such as that with which I have long been associated, and how important these activities are with our widespread plants, and the diversity of our products. There is corporation-wide stimulation and control from headquarters groups, as well as more detailed development and control at division and department levels. There are internal standards, and external standards as governmental requirements, legal responsibilities and moral codes apply.

The week before last I served on a panel of four at one of the so-called "workshops" of the President's Conference on Occupational Safety, held at the Nation's capital. The workshop had for its subject "Setting Safety Standards for Tomorrow's Materials." John R. Townsend, president of the American Standards Association, came up with the thought that "Standards are the pathway through the forest of technical development." How true this is in such newer fields of activity as nuclear progress, rockets, missiles, space travel considerations and the like.

But I like to look at standards just a little differently. There are standards of such fundamental nature that once agreed upon may never be changed. Your standard-gage track is an example. But I look upon most standards as representing a new tried and firm level or platform to which we have attained, where we may rest briefly or longer, only to move on to newer activities and needs beyond. Standards give us the security of position that allows us to spend our time, our manpower, our money, our energies on other problems, and to move forward. And of course each move to standardization must be surrounded with such care that there are open roads ahead. We must not paint ourselves into a corner, if I may use that expression.

There is no question as to financial returns from well directed standardization. To most of us in industry this is important. There is no question but that standardization of proper sorts leads to greater efficiency in many ways. To service organizations

such as yours, it can mean much to your customers in rendering more trouble-free service and in maintenance problems. And to a great industry like yours, contributing in such large measure to our national life and well being, its value should be extremely great.

The program indicates that the general purchasing agent of a large Eastern road will follow me on this program. I have worked closely with many purchasing agents and purchasing people. The purchasing agent at my division of our corporation is a very active member of the Standards Engineers Society. To him, standards are a tremendous factor in the three matters in which he is most concerned—quality, procurement, costs. Purchasing and standards go hand in hand. Clear standards provide a common language; they make for reliability and reproducability; they make possible stores stocks no matter where the storage takes place; they make possible better inventory control; they reduce investments in tools and equipment. One hears complaints of "feast and famine" buying in many industries, and I hear that your industry may be guilty of some of this. Standardization, properly controlled and regulated, could help in this.

One hears much of manpower problems in these days and those ahead. The shortage of engineers and the most effective use of engineers are much discussed subjects. Standardization is of tremendous value in this problem. May I use one example, with which you and I are familiar. It required 15,000 pages to publish the 2,645 standard specifications and methods of test, issued in 1958, and the ten supplements in 1959 of the American Society for Testing Materials. These are under the care of 85 main committees, with approximately 9,500 persons who are members of ASTM or who represent members, plus some 600 or more who do not have any membership connections. And then the work represents the contributions of many thousands who went before, and the work of research institutions and industrial and commercial laboratories. One can get much engineering when he uses standards. The creation and use of good standards will free engineering personnel to move on to other and more difficult problems.

I referred earlier to developments in Europe. International standardization is a much discussed matter at this time. Our lack of participation in international standardization is being held as a threat to American industry. This probably means less to your industry than to many others. It is, however, worthy of note. Something over a year ago, Time magazine dealt at some length with the subject of international standards. It seemed to feel that while showing the world the benefits of standardization, U. S. firms had done a poor job of helping to set up worldwide standards. It felt that U. S. firms have often taken notice of international standards only when they were being hurt. The Time article had the title "Industrial Conformity." And then, within a few weeks there appeared an article in a widely read magazine The Saturday Evening Post, a most thought-provoking article under the title "The Curse of Conformity."

In September of 1958, ASME Mechanical Engineering contained a most timely and thought-provoking article "Keeping Codes in Proper Perspective." The author was concerned over what he calls a trend towards "handbook or codebook designing." I think that you and I can agree that we've seen evidence of this in some places. Handbooks and codebooks are guides, some may even be the law, but they are tools to use and help us—I am not even suggesting that standards can replace good engineering judgement and abilities.

As some of you here may know, I have been a voice, more or less crying in the wilderness at times, for better attention to identification. To me this is a most important

and necessary part of all standardization of material things. It becomes increasingly important as life and material things become more complex.

I have been perturbed in several cases in recent years, where there were delays in even attempting to arrive at standards, by uncertainty, fears of the initial costs involved, of how long it would take, and whether it would really be a good standard. To me a good cautious beginning, not too much, getting something down to look at, or even try, is often very helpful to the problem.

Several years ago, in Washington, when serving on a panel discussion of the American Standards Association, an age-old question was raised by a worthy admiral of an European navy. Did we not think that standardization hinders, stifles, or even prevents development? Does it regiment to the place that it hurts? So many people and interests ask this question. Many who dislike standards ask it. But some who ask are really sincere. The idea of limitations has never appealed greatly to Americans, as well as to other people.

Felix Reisenberg in his "Endless River" dealt with this problem in an interesting way, and I quote:

"Have you ever considered that if every thumb print is different, perhaps everything else is different? No two people are alike. Yet originals, individualists, bright intellects, and the gang who lead the laughter and point the way, are alarmed by an idea that we are becoming standardized."

Does it not follow that engineers will not stop long with even a standard that bears improvement. There's always room for better standards—and to me, there is probably more chance of improvement from the level of a good standard than from the shifting sands of whim and fancy. Also it is worthy of note that very often in standardization activities, we will create special things, different than the standards, to meet new or extra requirements, and these later supplant the older standards. I am sure you have had this experience in your rolling stock as demands of your customers change.

Not so long ago, here in Chicago, some of my friends in the utility field presented an interesting problem. It is good practice to periodically examine large bolts and studs that have been in highly stressed, high-temperature service, to be sure that progressive cracking has not started at critical points. Ultrasonic methods for doing this have been developed. It had become more or less the standard to finish these studs or bolts with either spherical or practically conical ends. The ultrasonic examination makes a flat surface more or less necessary for applying the crystal of the sonic device. The question was raised as to why not finish these ends off square or flat. I cite this to illustrate that awareness of needs, new practices, etc., must be recognized in standardization activities.

At the ASTM meetings in St. Louis in the spring of 1958, one of the luncheon speakers said something that all of us could well afford to heed. What we need, he said, are standards that cover today's practices, not records of what we did yesterday. No matter what particular fields of standardization we may be interested in, or talking about, this feature is very fundamental.

I view with much concern the creation of new standards or allowing existing standards to continue, labeled as standards, when they do not reflect today's practices. I object to spending time and money and energy creating new standards or revising old ones, when the consumer representation involved will all go out and write private specifications of an up-to-date, more exacting nature, and the producers involved will accept orders to those higher grades, and the so-called standards are not used.

I object, too, to a practice that will hand out those non-used specifications with the statement that "our specifications are better than the standards," when they helped

create those non-used standards. Likewise, when we distribute those same antiquated or non-used standards to others, for example to those in foreign places, what must they think of the technical society or other organization that keeps such things on their books?

There is another matter that I think should concern all of us. I mention it because it does have its application in material things, and in standards activities. We are now living in a remarkable age as regards communication and advertising. I have commented on this publicly years before any present national concern. The radio and television have brought us in touch with the very finest and the very lowest of communication and advertising. Never have we had so much printed advertising—never so many "free" magazines. It appears to me that our standards have been lowered, and that new higher standards should be our aim. Truthfulness and honesty should always prevail. Yet we all see much in communication advertising, where the principal says things or uses illustrations so designed as to guide the hearer or observer into an incorrect or untrue impression, favorable to him, unfavorable to a competitor. He defends himself that he said nothing wrong; the recipient just jumped at conclusions.

Some have asked a most intriguing question—"After the standard—what next?" I think already I have hinted at the fact that few indeed are the created standards from which there will not be new standards, improvements, developed as experiences grow.

A good many years ago, when especially impressed with conditions arising from wars and depressions, I made the somewhat dubious remark that those in two vocations in life need never lack for employment, that is, lawyers and accountants. To these, I have added "standards engineers." The work that they can do is indeed limitless in our diversified industries of today. And may I conclude by using the slogan of the 1956 ASA conference—"Standards Are Everybody's Business."

There are many other random thoughts regarding standards that I should like to discuss, but these must be left to other times and other places. Standardization is many things, in many fields, for many purposes. It is educational, no matter what field we are in. Henry Brook Adams in "The Education of Henry Adams" made a brief comment that I would use in closing:

> "From cradle to grave, this problem of running order through chaos, direction through space, discipline through freedom, unity through multiplicity, has always been, and must always be the task of education, as it is the moral of religious philosophy, science, art, politics and economy."

This is standardization. It is not something to enslave us, but rather it is a tool, fitted to our hands to use, and its proper use will yield worthwhile returns in efficiency, in services, in time and in money. [Applause]

President Woolford: Thank you, Mr. Mochel. In the interest of saving time, or of giving the time to others, I shall refrain from commenting upon your remarks at this point, or upon the remarks of the other speakers in our symposium, hoping that at the end of the symposium as a whole, time will permit at least a few comments from the floor.

As the second speaker on our symposium this morning, I would now like to present to you Mr. J. S. Fair, general purchasing agent of the Pennsylvania Railroad and a past chairman of the Purchases and Stores Division, AAR.

Along with many others on the railroads in a similar capacity, I know that Mr. Fair feels the Purchases and Stores Division has an important stake in this matter—

a feeling which he has expressed on numerous occasions, and which has been set forth unmistakably in recent reports of the Purchases and Stores Division. Without further encroachment on his time, may I present to you Mr. J. S. Fair, the eminent chief purchasing officer of the Pennsylvania Railroad. Mr. Fair.

The High Cost of Being Different

By J. S. Fair, Jr.

General Purchasing Agent, Pennsylvania Railroad

Thank you Mr. Chairman. Ladies and gentlemen, I would like to report payola in the AREA. This necktie I have on is a Western Pacific necktie presented to me by Mr. Frank Woolford after I had commented on the terrific sales pitch that he and Neal Howard had put on. I would like to suggest to any salesmen if you would like to learn how to write a letter, just ask them to tell you. They can really do it.

As a past chairman of the Purchases and Stores Division, I would like to bring you a brief greeting. We fellows have a very high regard for the American Railway Engineering Association. We learn a great deal from you. We have a lot more to learn. And Neal Howard has been particularly helpful to us in our work. It is a pleasure for me to be here as a mechanical engineer who went off standard and became a purchasing agent, to talk to you a little bit about what the price tag is in not using standards. I have called this paper The High Cost of Being Different.

The basic responsibility of management in any industry in the American economic system is profitable operation. Those who have invested funds in a company are entitled to a reasonab'e return on the money they have put into the business. It is well known by all of us that the rate of return of the railroads is far below that of other industries.

It is the constant objective of railroad officers to control expenses so as to improve the meager profit which is typical of most railroad companies. The broader application of standard designs is one weapon available in this battle, which has been only partly exploited. It provides a means of lowering the cost of materials, improving their availability, and reducing inventory.

It is true that some of the benefits would be more readily available in certain materials than in others. In the case of rail, for instance, it will take years for us to work out of track all the odd sections if we now decide, as we should, that we will adhere to 8 or 9 sections instead of continuing to buy 43 or more sections. This should not prevent us from proceeding with a program which will benefit the industry.

It is also true that what we need is lower total cost—when we save in price, but find ourselves with higher overall maintenance cost, lower prices are false economy. However, there is reason to believe that our non-adherence to standards has been due to personal whims and "pride of authorship" rather than to factual determination as to whether an existing design or a new design worked out through joint effort with others, will produce equivalent or better results. We need a willingness to work together, sharing the benefits of tests and experience in open-minded consideration of the designs that will do the most good for the most railroads.

Standardization as we are talking about it does not smother progress by stifling research and development. It is the drawing of fine-line distinctions in design and specifications which we question. This has raised production costs and presented the problems we now face. For instance, there is no question as to the progressive need for heavier rail sections as the railroads developed their techniques from 1850 to 1960.

However, there is ample basis for asking why we have to have 9 different sections of rail, each weighing 100 lb per yd.

One rail mill has provided information which will be helpful in understanding the relative cost to produce a few sections of rail as against many. The railroads, of course, pay the bill for the extra work in the established price for rail.

This rail mill now produces 22 rail sections, 5 of which are among those being considered by the AREA as potential standard sections. If their rolling were limited to those 5 sections, this is what would happen:

Ingots—They would cast 5 different weights of ingots instead of 10 different weights for the 22 rail sections.

Blooms—3 different cross sectional areas would do the job, as against 5.

Bloom weights—At the bloom shears, the 3 different-sized blooms needed for 5 rail sections would be cut to 7 different lengths, but to produce 22 rail sections, the 5 different-sized blooms would have to be cut to 23 different lengths.

Every time there is a change in ingots, blooms, or rail sections there are added production costs. If it is in ingots, a different mold must be taken from storage and brought to the pouring floor. If it is in blooms, mills must be reset to change the resulting cross section, or the shearing process altered to produce longer or shorter blooms.

There are as many as 14 rolls in one set required for rolling certain sections of rail, and each roll must be set in place before production can be started.

Investment in rolls—Figuring on only one set of rolls for each section, the investment to produce the 5 sections would approximate $186,000. The investment to produce 22 sections would be about $754,000.

The interest on the latter investment in rolls is $37,700 annually at 5 percent, and we pay for it. If we had used only 5 sections, the bill would be $9,300.

In 1957–1958 four of the five steel companies then producing rail collaborated with the Purchases and Stores Division's Committee on Standardization to develop some of the costs resulting from our having so many different sections of rail. The following are some of the highlights of their findings:

a. The four companies had $11,900,000 invested in rolls.

b. The interest on this investment at today's prime rate is well over a half million dollars per year.

c. The four companies average 10 roll changes per month, which requires 57,800 man-hours per year, or about $160,000 at today's wage rates.

Rail has been used in this discussion because it is, first, familiar to all of you in the AREA. Secondly, we have some fairly good cost data on rail; and finally, it is an excellent example. Not only is there much to be gained in standardizing rail itself, but it offers tremendous possibilities for savings in other track material.

Having seen the effect on production costs of different sections of rail, it is not difficult to visualize, for instance, the complications we impose on manufacturers of joint bars which are rolled much like rail. In bars, however, we are not content to insist only on different sections, we throw in different lengths and punchings to further increase the cost and consequently the price.

In frogs and switches we have really exercised our talents for the different. At one plant producing frogs and switches they have the templates, patterns, tools, drawings, and materials to make 177 frogs, 143 switches, and 41 guard rails, all for 115 RE rail. For 90-lb ARA rail, the oldest in service, there are 400 different frogs, 109 switches, and 88 guard rails.

Referring again more directly to costs, let us consider rail anchors a relatively simple device compared to complicated assemblies such as switches and crossings. A leading rail anchor manufacturer finds that his cost for labor, dies, and plant engineering is 9 times as high for special sections of rail as for standard sections. He is called upon to produce non-standard-section anchors 50 or 60 times a year.

The kind of standardization that will produce lower cost materials is not limited to track materials. On the contrary it also applies in the design of freight cars, structures, signal material (for instance, Mr. Smeltzer has 87 bootlegs, 600 plus rail bonds), and even down to printed forms. It calls for a knowledge of how things are made, the cost to make them, what are standard readily available components, and what will they do. An able engineer is as aware of cost as he is of engineering fundamentals and the job he wants a part or assembly to do. Frequently he must use his skill and imagination more to make use of an available item than he would to design a different one. The rewards are lower cost without sacrifice of performance, better availability, and less inventory.

The railroads have spent approximately $1.7 billion dollars annually for fuel, materials, and supplies in recent years. Some of these materials present the possibility of ultimately saving 5 percent in prices through standardization, as in the case of rail and other track material. Others would be less productive of lower prices, such as timber and lumber, but in any materials, standardization produces lower inventories and better availability.

If we accomplished only an average reduction in price of 2 percent on half of what we buy, the saving would be $17,000,000 per year in cost of materials.

We should also be able to reduce our inventories by $20,000,000 on a conservative basis. It is generally recognized that it costs between 15 and 20 percent of the value of material to stock it. If we use the low figure, this reduction in inventory would save $3,000,000 per year.

Thus, conservatively, standardization offers the possibility of reducing railroad expenses $20,000,000 annually.

On the capital-equipment side the rewards for standardization are equally, if not even more, inviting.

To eliminate all freight cars over 20 years old within the next 10 years would involve replacement of more than 1,128,000 cars, or an annual average of more than 112,000 cars. The National Association of Shippers Advisory Boards has suggested that the total freight-car fleet should approximate 2,000,000 cars, as compared to the present 1,700,000. If in the next 10 years we were to replace the over-age cars and increase the fleet by 300,000 cars, then we would have to acquire more than 142,000 new cars each year. In order to keep our estimates on the conservative side, let us assume that in the next 10 years our industry should be building 120,000 new freight cars annually.

There is an increasing demand by rail shippers for specially equipped cars of various types. Some of these special cars require significant divergence from normal design in the basic characteristics of the car, to accommodate unusual lading. Most requests of shippers, however, are for "normal" cars fitted with load-restraining devices to reduce the potential damage to lading and facilitate loading and unloading, with proportionate reduction in expense to the shipper.

If the railroads had a commonly agreed upon and used standard design of each of the four basic types of freight cars—i.e., box, gondola, hopper, and flat—these "standard" cars should still meet the needs for three-quarters of our new car requirements.

It is conservatively estimated that the cost of new freight cars can be reduced $200 per car if all cars were built to a standard design. Thus if our industry is to need 120,000 cars per year, and on the average three-fourths or 90,000 could be standard cars, we would save $18,000,000 annually in the cost of those cars if we could adhere to standard designs. This sum would pay for building an additional 2,000 new cars.

There is indeed a substantial price tag on "being different", and the rewards for standardizing are substantial. [Applause]

President Woolford: Thank you Mr. Fair: Again, I must refrain from commenting upon your remarks, except to say that you have very ably represented the purchases and stores department of the railroads in this matter and make a very convincing case for increased standardization.

Proceeding with our symposium, we will next hear from a representative of the railway supply industry, because if further standardization on the railroads reaches back into the mills and plants of our suppliers, with advantages both to them and the railroads, we want to know more about it. As our next speaker, we will hear from Mr. J. P. Kleinkort, manager, Railroad Products Division, American Brake Shoe Company, who will deal with Standardization—As the Trackwork Manufacturers See It. Mr. Kleinkort.

Standardization—As the Trackwork Manufacturers See It

By J. P. Kleinkort

Manager, Railroad Products Division, American Brake Shoe Company

Mr. President, AREA members and guests: I appreciate very much the opportunity to talk to you on the subject of standardization, which the manufacturers would like to see applied more extensively to trackwork.

I am employed by the Railroad Products Division of the American Brake Shoe Company, which manufactures, among other things, a sizable percentage of the special trackwork you railroad engineers install and use.

Basically, many of us dislike a standard item for personal use. We generally seek something different and better to avoid copying another's choice. We may do this about personal things, but when it comes to railroading we must place costs and quality first and personal likes and dislikes second. A railroad today must be operated at a competitive cost to be able to exist. Our attention, all of us, user and supplier alike, must be focused on cost and quality. Standardization can help us to attain this goal.

AREA standard trackwork plans have been and still are the recognized standards for railroad trackwork here and in many parts of the world. Inquiries for American-made trackwork received from other countries of North and South America frequently refer to these plans in their specifications.

The principal reasons why the railroads which do use AREA standard plans cannot use them interchangeably is because of the many variations from AREA standards in rail section, drilling for joint bars, and use of various AREA alternates. In addition, there are too many standards, or enough different ones, to please all AREA members. This kind of a problem, plus a delivery problem, on the Missouri Pacific Railroad, one of our East St. Louis Plant customers, late in 1955, proved to be the birth of a new demand for standardization in trackwork. A representative of this customer was visiting our plant to expedite his order and noticed several stacks of finished frogs and switches in our loading yard. The railroad for which we had manufactured this track-

work had asked us to defer shipment. As you may have suspected, the customer who was in a hurry could not use the product we had in stock. The design was not interchangeable.

Through cooperative efforts, our engineers and the engineers of the Missouri Pacific, Frisco, Kansas City Southern, Terminal Railroad Association of St. Louis, and several others, agreed on a single standard for frogs and switches for use with 115 and 132 RE rail. By the fall of 1956 the plans were ready, and trackwork for 1957 rail programs was purchased to this new design.

After this experience we invited a group of maintenance engineers from railroads in the Chicago area to discuss the possibility of either using the Southwestern standards adopted at St. Louis, or a single AREA standard to give similar advantages to railroads in Chicago. These meetings were not as productive as the St. Louis efforts largely because there were more railroads involved, and the differences in standards were more pronounced. They did, however, create more interest in simplifying AREA standards and focused more attention on this subject in AREA. To help stimulate more action and a better understanding of the problem, we published an article on trackwork standardization which appeared in several railroad magazines.

Our company believes that these activities helped to spark renewed interest in rail and trackwork standardization, and this has been demonstrated by the following record of events:

The June 1957, Purchases and Stores Division report contained a very effective treatise on the cost to the railroads of a lack of standardization in rail and rail drilling for splice bar connections.

The Purchases and Stores group also sponsored a panel discussion on standardization during its June 1959, meetings, concentrating on car parts and trackwork.

During the last three years all of us have heard railroad officers publicly state the need for standardization of all the products railroads use. Most manufacturers and railroads are now actively promoting it.

During the past two years the AREA Committee on Track has made special efforts to bring out a simplified standard for trackwork which will be presented to the AREA at this March Convention.

During the past year a number of large and small roads have been and are still working diligently on a single standard for their trackwork requirements.

This sequence of events clearly proves that the vast majority of railroad people now believe that standardization is something we must have and is well worth the effort and sacrifice involved.

To help each railroad make a decision on all the facts, I will try to explain the reasons why we as manufacturers are interested. We know railroads need to reduce costs constantly to compete for traffic. We believe we can help them to do this through more standardization. That's why we have been promoting it for the past five years.

Based on 1958 dollars, the railroads purchase about $30,800,000 of special trackwork yearly. We estimate, based on a study at our largest plant, that only about 72 percent of this sum, or $22,176,000 worth of material can be standardized. We estimate that the minimum savings to the railroads if all this material were standardized would be 5 percent, or $1,108,000 annually. The railroads themselves would have considerable savings, which can be proven by studying savings on other standardized products they use now.

It is entirely possible that the savings to railroads will exceed the 5 percent we have mentioned. A lot depends on how much standardization can be achieved by the various railroads, because the volume of standard work will determine the savings that can be

realized in a given trackwork plant. The total savings predicted will not be possible for several years because, even if a concerted effort is made at once by all railroads, only a part of their requirements will be made to the new standard. To gain the maximum advantages they must start now and purchase all possible requirements to a simplified uniform standard.

It may be of interest to you, and others, how and why we can accomplish this saving, and I therefore mention the following contributing factors:

Shop Production:

Simplified scheduling of production.
Stabilized production.
Less supervision and shop inspection.
Less down time on machines for changes.
Reduction in material handling.
Simplified use of templates and other necessary measuring devices.
Less machinery required.
Less pattern equipment required.
Less storage for patterns.

Materials:

Reduction in volume of materials
Reduction in variety of materials.
Reduction in inventory of materials.
Less storage space for materials.
Less personal property tax on inventory.

Office Expense:

Simplified selling.
Reduction in preparation of drawings and bills of material.

Purchasing:

Simplified purchasing.
Buying in larger quantities at lower prices.

Accounting:

Reduction in timekeeping.
Reduced accounting expense in payroll and material costing.

Many of the individual items mentioned account for small savings, but together they account for real savings.

These savings would not be possible on about 28 percent of what the railroads buy in special trackwork, such as railroad crossings, odd angles of turnouts and repair parts to existing turnouts. Very little can be done to eliminate these special items.

As most of you know, railroads generally have improved their efficiency in keeping inventories at a lower level. Standardization can further reduce this inventory. Because of the practice of maintaining lower inventories, we are called on to produce in even smaller quantities at more frequent intervals and always on a rush basis. This practice forces costs up.

To give you a better understanding of some of our problems, I would like to tell you what happens to us in a typical year. First, we receive the major part of our annual business during the months of December, January, February and March. During the balance of the year railroad orders are reduced 25 to 50 percent. What happens in our plants? We don't have enough work to keep all our men employed. Result—we lose a group of men, and the best ones don't return. When the next surge comes on in

December we must hire new help, and train them to operate machines that are very special. Because these machines cost in the vicinity of $100,000 to $150,000, we must keep supervisors with these men until they have sufficient knowledge to operate the machines without damaging them. As you might suspect, the work performed by these men is at a slow pace until they become experienced. Thus our costs are forced up by extra supervision and slow production on expensive machines. If the machined parts are not to correct size or shape, the assemblers cannot put the trackwork together until a new piece is made. The manufacturer must scrap the material, pay the assembler while waiting, and pay the planer operator for making up the new piece. While this is not a daily occurrence, it does happen frequently when new inexperienced help must be employed.

It is not possible to hire experienced help because the special-trackwork industry is a small one.

What Railroads Can Do to Help

Actively support the efforts of the AREA Committee on Track which has a subcommittee working on further reducing the quantity of standards and alternates presently in the AREA Portfolio of Trackwork Plans.

Make use of these simplified standards in the purchase of track materials for their new rail programs, even though such standards might initially be slightly more expensive than they would normally purchase. If this is so, it would be because of better design and safer and longer-lasting construction.

When existing turnouts require major repair or replacement of major parts, replace the turnout in its entirety with a standard turnout, keeping the usable parts for repairs to similar turnouts. In this manner they will eliminate the purchase of special materials and at the same time expand the use of standard items. Some railroads are doing this in a small way now. How much of this can be done, can easily be determined by individual railroad maintenance engineers, since each one has different problems.

Strong efforts should continue in AREA to simplify standardization and provide a sound standard that can be followed by all railroads. This would make it possible for railroads to interchange material and avoid delays of many kinds. They could carry lower inventories, get quicker deliveries, and obtain all the known advantages of using a standard product.

The present trend toward mergers is another and sound reason why railroads should speed standardization. The many advantages of merging can be further enhanced if standards used by two merging railroads are similar. Trackwork taken up can be reused and stock items used interchangeably.

In conclusion I can say that standardization will lower costs and stabilize employment in our plants; and help us to use labor, material, and machines, more effectively. The savings in cost will give railroads a lower competitive price, enabling you to improve your competitive position and improve your earnings.

If we do not standardize, our costs and therefore our prices for special trackwork must constantly go higher. We believe it is obvious what must be done. [Applause]

President Woolford: Thank you Mr. Kleinkort. Representing at least one important segment of the railway supply industry, you have made a substantial contribution to the evidence in this case, many aspects of which I feel sure apply to other segments of your industry as a whole. We particularly appreciate the interest of your company in

this matter. Certainly, the railroads cannot afford to overlook the sizeable saving you cite through increased standardization in special trackwork.

No picture of this subject of standardization would be complete without hearing from the user departments of the railroads and, while time would not permit arranging to hear from all of the different departments involved, our program does provide for hearing from one of the most important departments and the one of most direct interest to most of us. Our next speaker, therefore, will be Mr. R. H. Beeder, chief engineer system, Atchison, Topeka & Santa Fe Railway, who will speak on Standardization —From the Standpoint of the Engineering and Maintenance of Way Departments. Mr. Beeder.

Standardization—From the Standpoint of the Engineering and Maintenance of Way Departments

By R. H. Beeder

Chief Engineer System, Atchison, Topeka & Santa Fe Railway

Standardization—What a subject! I am sure one can start much discussion—much heated discussion—leading almost to fisticuffs just by mentioning the word Standardization.

I told President Woolford that we four draftees on this Standardization Symposium would be about as popular as porcupines in a balloon factory. President Woolford just smiled.

Why is this so? I feel that the lack of standardization in the past has been partially due to the fact that we are all different. We are different in personality. We are different in our ability to evaluate scientific results.

I am sure we must and will retain most of our personality differences. That is the American way of life. That is as it should be in a democratic society.

These personality differences determine the kind of automobiles we drive. They determine the kind of cigarettes and cigars we smoke or do not smoke. I can vouch for this as the only time that I am man enough to smoke a cigar is when I am attending an Irish Wake. These personality differences even determine the kind of girl we want to propose to us.

We can advance the known economic advantages of standardization by relying more on known scientific results and by swallowing at least some of those personality factors that influence us. They are a lot more prevalent than they should be, and now is the time to advance toward the standardization of the materials used by the engineering and maintenance of way departments of our railroads. This is especially true of our rail sections and fastenings, as well as turnouts.

Any railroad can, within its own organization, make a reduction in its inventory of track material by restricting any future purchases of new rail to one or two rail sections and by the use of fewer designs of turnouts. Of course, such a program on an individual railroad might not necessarily bring about all of the benefits that we desire. You and I know that each individual railroad might adopt different standard rail sections and turnout designs in reducing their own inventories. This sort of a solution would not bring about the economic advantages that would result from the general adoption of uniform standards by all railroads, or at least by all railroads within certain geographic limits, because it would still be possible to have too many different designs to reach suitable mass production figures that are needed to reduce manufacturing costs.

Any approach to standardization would have to start with certain selected items that we use, and we feel the proper place to start would be with rail sections. We cannot very well standardize on joint bars and other track fastenings or even with turnouts until we reduce the number of standard rail sections to the minimum. We now have six recommended rail sections in the Manual, ranging from 90 lb to 140 lb, and it would appear that this number could be reduced to three sections, one for light, one for medium and one for heavy service and traffic conditions. Later on, we might eventually arrive at only two standard rail sections, one for medium and one for heavy service and traffic conditions. Such limitation would mean that yards, sidings and secondary lines would be laid with secondhand relay rail of the medium weight that would be recovered after main track usage.

We we talk about standard rail sections, I do not want to infer that these sections must necessarily be selected from the present six rail sections in the Manual. Some new rail sections have been developed within the last five years which have a contour and physical properties superior to some Manual sections for practically the same weight. Engineers well know that, even if the weight and contour of some sections is nearly the same, the contour and physical properties are of extreme importance in the service life of the particular rail section. There seems to be a trend within non-engineering groups in the railroad industry to inspect the contour of many rail sections without any evaluation of physical properties and describe the differences in rail sections as minute and question the necessity of having rail sections that appear to be similar to each other. I wish to take strong objection to that thinking. It certainly is not a conclusion that would be drawn from an engineering standpoint. These differences may appear "minute" to some, but they are of extreme importance in the service life of a particular rail section.

Other trends that will lead to wrong conclusions are attempts to hold a sort of a popularity contest to determine our standard rail sections. In my opinion, it is illogical to conduct a popularity contest to determine the most useful, serviceable and economical rail section by adding up the production of certain rail designs from some of our rail mills and select those rail sections on the basis of highest tonnage rolled. Certainly the selection of standard rail sections should be on a more scientific basis than the results obtained from such methods.

We are very glad to see that the Rail committee is looking into the matter of standard rail sections and that the AAR research staff is making laboratory tests of comparable rail sections in order to find the best possible sections. We are extremely hopeful that something definite can be arrived at this year, and the Rail committee may be able to submit their recommendations to you for action at the 1961 Annual Meeting.

The things that have been said about rail sections would also apply to joint bars. Stiffness and strength of joint bars are of extreme importance, especially so at this time, with the greatly increased use of welded rail. We should have the best possible joint at the ends of strings of welded rail. Consideration should be given to the fact that long-toe bars are considerably stiffer and stronger than short-toe bars, and as the number of joints per mile have been greatly reduced by welded rail, the more expensive long-toe joint bars can be economically justified. This is true even though the few long-toe bars that are required must be accompanied by three especially punched tie plates. Our Rail Committee also has jurisdiction over rail joints. We are hopeful that this committee will analyze this subject carefully and submit its recommendations for standard joints at the same time as they submit their standard rail sections.

The AREA Manual shows rail drilling and bolt diameter for each rail section. The horizontal spacing as well as the size of the holes and diameter of the bolts were

arrived at after extensive field tests and have been found entirely satisfactory by all roads that have used the AREA Manual recommendation. We on the Santa Fe can speak from personal experience, as we used different horizontal spacing for some time with unsatisfactory results and came back to the present AREA standard. In my opinion, the present spacing and size of holes, including bolt diameters, can be applied to any rail section recommended as standard.

Now turning to standard turnouts. We note from the Track committee report that it is recommending five standard turnouts. Three of these are for main tracks and two for yards, which includes one turnout for very restricted locations on account of limited space. This is considerably better than the 13 turnouts now in the Portfolio and certainly a long step in the right direction. It will be interesting to see the reaction of our membership when this report comes up for discussion. Some roads may be reluctant to give up their own designs and ideas or they may be unwilling to face the problems such designs might create on their own properties. Some additional costs may be involved initially, but the long-range viewpoint would be in the direction of economy. These considerations must be faced, however, if we bring about general standardization for the future economic benefit of all.

Undoubtedly, there will be some problems connected with standardization. Perhaps some of these will be brought about by some misinterpretation of what standardization means. In my opinion, standardization does not mean freezing some particular type or design forever and then staying continuously obligated to its use. I believe standardization is an active and dynamic concept that carries with it the obligation for continual improvements, with the added responsibility for all of the railroads to act as a group in the adoption of any such improvements.

There is no time like the present. Now is the time to start. [Applause]

President Woolford: Thank you, Mr. Beeder. You have rounded out our general discussion of standardization in a very able manner, and your comments are very much appreciated.

We all look forward to the special report of our Track committee on Wednesday morning, with its recommendations looking to greater standardization in track turnouts, and to the panel discussion on this matter to follow. I feel satisfied that if nothing more were to be said about standardization during the remainder of our convention, a major contribution has been made to the thinking of all of us on this important matter.

With one more important feature on our program this morning, and time running out, I am afraid that we must defer any general discussion of this subject to another time, but if there is anyone who would like to ask a question of one of our speakers, or would like to make a brief comment, I shall be glad to recognize him at this time.

I think you all realize that standardization is very near and dear to me and I certainly think this symposium we have had has been what we would call the icing on the cake, as I don't think we could have found four better individuals to have presented the subject before this group than the four we used this morning. You are now excused so we may proceed with our last speaker. Thank you, gentlemen.

President Woolford: Our next speaker comes to us with a most interesting and varied experience in all phases of railroading. Having joined the Southern Railway early in 1926, he has, through the utilization of his inherent talents, his early training at an outstanding engineering school, and hard work, mastered the many difficult rungs of the ladder of success, attaining the position of vice president of the Southern Railway System.

Our speaker is no stranger to most of you. We have observed his tremendous success with people, machines and modern methods of accomplishing the impossible. His success in the training and development of young men has been a guiding light in his success in modernizing the Southern's operations. Gentlemen, I am speaking of Mr. Dennis William Brosnan.

Mr. Brosnan spent his early life about Albany, Ga., wandering into the portals of that great old school, the Georgia Institute of Technology, at the age of 16. There, he was a most outstanding student and, I might add, a past master in the art of hazing. I know this only too well, as I still carry the marks of his heavy hand on the working end of a Phi Sig paddle.

Our speaker was graduated from Georgia Tech in 1923 with a Bachelor's degree in civil engineering. Immediately following graduation, he entered the service of an Atlanta building contractor in heavy construction, design and planning, later trying a fling at highway location, design and construction. In 1926, however, the railroad urge overtook him and he joined the engineering department of the Southern Railway. Here, he advanced rapidly through the ranks to the position of assistant engineer maintenance of way, then by-passed into operations, occupying the positions of trainmaster and superintendent, and then, in 1946, returned to the engineering department as chief engineer maintenance of way. Early in 1947, again the operating arm of the Southern needed Mr. Brosnan's untiring effort and foresight, and he was placed in the position of general manager, Central Lines, with headquarters at Knoxville, Tenn., where he remained until January 1, 1952, when he was made vice president, operations, of the Southern Railway System, with headquarters at our National Capital, Washington, D. C.

Because of Mr. Brosnan's experience with people, his outstanding knowledge of railroading, and his continual success in accomplishing his objectives through people, his message to us entitled, The Responsibilities of Maintenance Officers to Their Managements, should be both interesting and thought-provoking. I am pleased to present to you Mr. Dennis William Brosnan, vice president operations, of the Southern Railway System, better known to many of us as Bill. Mr. Brosnan. [Applause]

The Responsibilities of Maintenance Officers to Their Managements

By D. W. Brosnan

Vice President Operation, Southern Railway System

Thank you, Frank. You know, one of the nice things, but one of the most difficult things, is sitting and listening to your friends talk about you and then trying to live up to the billing that they give you. Frank has certainly given me a lot of billing here that I assure you I don't deserve. I just work around the Southern. But I do appreciate Frank's friendship and his high regard, which is fully reciprocated. He and I were in college together many years ago and we could tell some pretty good tales about each other, but I won't burden you with that right now. I understand you are short on time and I'll get along with what I have to say to you, which I hope will have some meaning to you.

Frank Woolford and I were college-mates and friends at Georgia Tech back in the 'twenties. I have followed with much pleasure his progress through the years, including his term as president of AREA. He put his suggestion that I take a spot on your program on a personal basis, which left me no room to refuse. Then too, it is an honor

to take part in an AREA program—since AREA is one of the oldest and most respected professional engineering societies. Its contributions to railway progress and to the field of engineering, in general, has through the years been most substantial. This has been due to the quality and endeavor of the men who make it go. Hence, it is really a pleasure to have this opportunity to point out to you what I conceive to be some of the responsibilities of railway engineering and maintenance of way officers to their managements, and thereby possibly contribute something of value to your deliberations.

In the first place, the railroads are in dire need of the very best thinking and action that all of their officers are capable of producing. The march of technology has been as rapid in transportation as it has in other fields, and living in an age of such change makes it imperative that all people and all businesses continuously adjust themselves to those changes and the economic winds which blow from them.

In addition to the changing times in which we live, the railroads are operating under many outmoded regulatory practices and face highly subsidized competition which has managed to keep the door closed to the railroads' efforts to utilize public highways, waterways and airways in a coordinated transportation service. Time does not permit me to dwell here on these features, as real, as damaging and as unfair as they are, and as much as they may lack fulfilling the best public interest, so I will confine my remarks to what you men can do in today's technological and economic market to better serve your companies.

As I see it, each of you, from the system chief engineers to and through the ranks of supervisors, has a definite opportunity—in fact, a duty—to perform in forwarding the welfare of your respective companies in the engineering and maintenance of way field.

First of all, each of you bears a moral responsibility, which you cannot escape, to give to your company continuously the best that you have to offer in the way of devotion to duty and forward-thinking in engineering and maintenance matters. There is far too much lassitude, or a feeling of "let someone else do it." Each and every railroad has need for the best use of the brains and abilities which are represented by you men.

I might say this: In my judgment, the very best brains in American railroading are represented in your group, and it is high time they were more fully utilized, both by some activity on your part and by recognition of rail managements as to just what they are passing up when they fail to utilize them.

You cannot sit idly by and fail to keep abreast of the technological and economic changes that are taking place today and the opportunities which they bring to lower costs and at the same time to better services and maintenance conditions. Duty demands that you take a part by keeping informed of technologies in, as well as outside, the railroad industry and think in terms of adapting such things to your own maintenance programs.

Having kept in touch with economic and technological changes, and adaptions which are possible to your company, it is your duty to inform your superiors and discuss with them the improvements and economies which can come to you from such applications, and not do it in a halfhearted or apologetic manner. It should be based on sure knowledge and be presented in a forceful manner, spelling out in dollars the returns which can be expected.

Your management has a right to expect this from you. Far too many railroad officers are content with the status quo. They are not looking for any activities that look as though they might bring either more work or additional responsibilities toward them. There really is no place in this or any other industry for people of this character. They simply are not worth their salt.

At the same time management people have a duty to hear you out—to encourage you to do forward-looking planning. Above all they should not take the easy route of postponing realistic, dynamic decision on your recommendations. Far too many officers in management take this dull and discouraging view. They should set an example in progressive, energetic action.

Thinking in terms of maintenance and engineering, it seems to me that it is the duty of each of you men to know what is being accomplished on other properties in the way of track and bridge maintenance—what methods, what organizational plans of men, materials and machinery are utilized to effect maintenance, and what costs are produced by such methods. These costs can be foretold with remarkable accuracy, both on other lines and in anticipation of their adaption upon your property. Half-knowledge is useless, as is a weak determination. You should know all of the facts and accept them in an unbiased manner, looking at them in the cold light of reason. You should have a forward-looking approach, not a negative view, in examining such procedures. I refer to such common maintenance practices as timbering and surfacing, bridge painting, bridge repair, track smoothing, relaying of rail, and the construction of new track.

If your company is using any methods today that were in use 50, or 25, or even 10 years ago, you are wasting money, and you are failing to do your job unless you call attention to improvements which can be had. There are entirely too many "sacred cows" and too much "gay 'nineties" thinking in this industry, and, frankly, a large part of it rests with some of you people—to the detriment of your companies and your own opportunities. Far too many of you are engaged in the negatives—from such expressions as, "This will work on that railroad, but it won't work on mine," one would get the impression, speaking facetiously, that your company was using something other than rail to run on, or cross ties to hold the rail together. Most of the things that won't work are in men's minds and in their approach to life—that is, whether they are aggressive and dynamic in their thinking—search truly for the facts and then work diligently to sell their ideas to their superiors, and ever more diligently to see that success attends the use of new methods or equipment once it is installed. It seems that some of you are not looking for any new worlds to conquer, particularly if it looks as though some risk of either work or judgment is involved.

There are means available today which can produce better maintenance at sharply reduced costs, and produce longer-lasting maintenance. There are means today which can produce new track construction at costs of less than one-half that occasioned by some of the methods presently in use—mostly old methods— the pick-and-shovel and backbreaking way.

You engineers, in addition to responsibilities in maintenance, are charged with planning and designing of such things as yards, shops and other facilities. When you do this you have a responsibility to be forward-looking—to embrace the best that is available in technology and systems of work organization—to produce efficient, economical operation.

A yard is really a materials-handling operation. It is subject to assembly-line treatment in the same fashion as is the assembly of automobiles or other such products. Yards should be designed so that when cars come in at one end they keep moving in one direction until they go out, and that there be no reverse movement of any cars. Such reverse movements help create bottlenecks and are the big creators of waste. This principle can apply to any yard, whether it be a large retarder operation or a small flat yard. What is involved is a matter of a dynamic application of principles as opposed to a static, or defeatist, "can't do" attitude.

In the design of a yard the important thing is to get cars switched; however, there are many smaller details that must have attention, such as car inspection, weighing, the preparation of switch lists, and a host of other items. Each of these can be attached to the main switching operation in such manner as not to hinder it if sufficient thought is given and easy, unrealistic answers are not sought. The right answers and the economic answers usually require some sweat to come by. This does not work for "pantywaists" or people who are easily satisfied with mediocrity.

You engineers have a similar opportunity for broad-gage thinking, innovation and creation in the design of shop facilities, such as heavy car overhaul shops, car running repair or rip tracks, locomotive maintenance facilities, either for running repair or heavy overhaul. To do a proper job you should attempt to find out some of the problems of the mechanical department officers and to get their view—what and why they are attempting to do—and this should be done in the most minute detail possible.

And I break away for a moment to warn you again that you don't come by something by the whole; you come by it by the parts, and the quality of the whole will be influenced by the quality of the parts, so that operation, maintenance and construction are really a bundle wrapped together that may be packaged. To the extent that the details are not properly handled, the final package will be defective.

This does not envision taking over the duties or responsibilities of mechanical department officers, but it does envision a genuine cooperation, seeking to aid by the application of your brain power and creative ability in producing jointly with the mechanical officers a facility which will produce the optimum of economy and efficiency. A similar attitude and approach by the mechanical officers is necessary in order to come up with a design for the best facility.

A lot of "sacred cows" exist in the railroad industry from pride of authorship, which is nothing more than petty jealousy—a failure or refusal to accept the thinking of others, even though it be better than anything that you have been able to produce. Such an attitude is a sure sign of a narrow-gage person and one who is not likely to accomplish much that is worthwhile in his living.

Don't get the idea that what I am saying applies to everyone else but you. We all need to examine ourselves coldly and in a calculating manner to be certain that we are putting real values first and that we are not letting personalities or our own egotism interfere with our pursuit of the best methods, the best thinking, the best planning, regardless of whose ideas may be used or whether they originate on our own railroad, or some other, or even whether they originate in our own country.

Your management has a right to expect from you as engineering and maintenance officers a reasonable compliance with the thinking which I have outlined, and, for that matter, to expect much more. To the extent that you faithfully discharge these obligations will you determine the contribution that you are making to your company and to this industry, and to a large extent the personal satisfaction which you can obtain from accomplishment. [Applause]

President Woolford: Thank you, Bill, for a most straightforward, to-the-point delivery to us today. I must admit that I tried all means to get you here and I succeeded. I would have felt remiss to this organization which had placed me in the position of president if I didn't have you here to give them a message. I think the record you have produced on the Southern Railway certainly speaks for itself. You have de-

veloped wonderful men. We asked for it and you have really laid it on the line for us. I am sure all of us, engineering and maintenance officers, recognize that we have responsibilities to our managements. The question may well be asked, however, whether we all recognize the character and extent of these responsibilities. Your address has certainly enlightened us on this point, and I am sure that everyone here will be a better engineering or maintenance officer for having heard you. Thank you again.

Gentlemen, Mr. Brosnan's address brings to a close our opening session, which has not only been most interesting but which I am sure has been profitable to all of us.

But this has been only the start of our five-session convention, with four more sessions ahead, each crammed with committee reports, Manual recommendations to be acted upon, and special features of one kind or another.

Early on our program this afternoon we have two other important addresses you will not want to miss. In fact, you can't afford to miss any of our sessions, and I hope you won't. The meeting now stands recessed until 1:30 pm, when I will expect you back here to resume our work.

[The meeting recessed at 12:22 pm]

Afternoon Session, March 14, 1960

[The meeting reconvened at 1:30 pm, President Woolford presiding.]

President Woolford: Will the meeting please come to order. We have a long and interesting program this afternoon, which will include the reports of six of our committees, four feature addresses, another symposium, and at least two motion picture presentations, which makes it imperative that we "get the show on the road" if we are going to keep on schedule and close out today's program by 5:30. I imagine all of you have appointments after that and we will certainly do our best to wind up at 5:30 or as close to it as we possibly can.

Discussion on Clearances

[For report see pp. 541–555.]

[President Woolford presiding.]

President Woolford: The "kick-off" report this afternoon will be that of our Committee 28—Clearances, of which S. M. Dahl, assistant division engineer, Milwaukee Road, is chairman. Will Mr. Dahl and the other members of his committee please come to the platform promptly.

While members of the committee are coming to the speaker's tables, may I ask that the chairman, vice chairman, secretary, and all subcommittee chairmen, especially those to present reports, take places here at the high-level speaker's table, as close to the podium as possible, and that other members of the committee fill out the main speaker's table and then find places at the lower speaker's table as may be necessary. This will shorten the time necessary for subcommittee chairmen to come to the podium to present their reports.

As another time-saving expedient, we have again this year provided the chairman with a microphone at his place at the speaker's table so he can make such introductions and comments as he desires without the necessity of coming to the podium microphone.

Before I turn the meeting over to Chairman Dahl, I would like to extend to all of you present the privilege of the floor and invite your comments on or criticism of any of the report presentations within the limited amount of time which will be available for discussion. For your convenience in this regard, portable microphones have been

provided in each main aisle of the room, and someone manning each microphone will be glad to bring it to you at your place on the floor upon your request, to the extent that this is possible. Gentlemen, this is your convention. Please feel free to speak and state your questions. We want them.

Mr. Dahl, before I turn the meeting over to you, I would like to make one announcement that will, I hope, help us keep this program going and on schedule. You will note that to your right and to my left I have placed a series of lights, which I will use as the program goes along with each committee. I will give them a flash with the yellow light, which means they have 3 min left, and when I turn the red light on, I want them to make their closure as soon as they can, so we can get on to the next subject. If each committee chairman will recognize that and try to help us keep the program on schedule, I know it will meet with the appreciation of everyone, and we will have a better convention if we don't use more time than allowed and run into the late hours and make you miss any appointments you may have.

And again I would like to extend to all of you present the privilege of the floor and invite your comments on and criticisms of any of the reports presented in the limited time that we have allowed for discussion. This is your convention, gentlemen. No convention is worth its salt if the membership doesn't participate. If you don't like the reports that are made, or if you have some questions or something you want to bring up, don't feel hesitant about doing so. Let's make this a meeting of the general organization. When you go to the mike, please state your name and the railroad you are connected with and speak freely. Don't be afraid to speak up.

I will now turn the podium over to Mr. Dahl, chairman of Committee 28.

Chairman S. M. Dahl: Mr. President, members of the Association, and guests:

It is with deep regret that I must announce the passing on January 14, 1960, of E. R. Word, a former chairman of Committee 28. Mr. Word was a member of the committee for 9 years and at the time of his death had worked for the Illinois Central in various capacities for over 44 years. His last title was that of special engineer.

The report of Committee 28 is found in Bulletin 554, December 1959, beginning on page 541. Manual material will be presented for adoption under three assignments.

Assignment 1—Revision of Manual.

Chairman Dahl: No revisions are proposed this year under Assignment 1. The subcommittee chairman is B. Bristow, principal assistant engineer, Chicago, Rock Island & Pacific Railroad. Mr. Bristow, will you please rise so that you may be recognized.

Assignment 2—Clearances as Affected by Girders Projecting Above Top of Track Rails, Structures, Third Rail, Signal and Train Control Equipment, Collaborating with Signal and Electrical Sections and with Mechanical and Operating—Transportation Divisions, AAR.

Chairman Dahl: The report on Assignment 2 will be given by Subcommittee Chairman J. G. Greenlee, clearance engineer, Pennsylvania Railroad.

J. G. Greenlee: Mr. President, members of the Association and guests:

Your committee submits for adoption and inclusion in the AREA Manual, a diagram of Clearance Lines for Third-Rail Territory. This diagram (presented on page 543, Bulletin 554, Vol. 61) has been developed through collaboration with the Railway Electrification committee of the AAR Electrical Section, and is identical to the diagram which appears in the Electrical Section Manual.

Your committee also submits for publication in the Manual, as information, Equipment Diagram Unrestricted For Interchange Service (presented on page 544 of the same

bulletin), to replace the two equipment diagrams now in the Manual, page 28-3-1, Equipment Diagram Unrestricted (Fig. 1), and page 28-3-2, Equipment Diagram Unrestricted For Main Lines (Fig. 2). The new diagram is identical to the Equipment Diagram Unrestricted For Interchange Service, of the Mechanical Division, AAR, known as Plate "B" and referred to in Car Service Rule 14(e) as the maximum dimensions for cars in interchange service.

I move that these diagrams be adopted for publication in the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 3—Review Clearance Diagrams for Recommended Practice, Collaborating with AREA Committees Concerned, and the AAR Joint Committee on Clearances.

Chairman Dahl: The report on Assignment 3 will be presented by Subcommittee Chairman R. L. Williams, special engineer, Illinois Central.

R. L. Williams: Mr. President, members and guests:

Your committee recommends that the following clearance diagrams in Part 2, Chapter 28, be reapproved without change: Fig. 1—Clearance diagram for railway bridges; Fig. 2—Clearance diagram for turntables; Fig. 3—Clearance diagram for single-track tunnel; Fig. 4—Clearance diagram for double-track tunnel.

Mr. President, I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Williams: Your committee also recommends that the following clearance diagrams in Part 2, Chapter 28, be reapproved with the revisions designated in the report of Committee 28, Bulletin 554, December 1959, pages 545 to 549, incl.: Fig. 5—Clearance diagrams for buildings and sheds adjacent to side tracks; Fig. 6—Clearance diagrams for warehouse and enginehouse doors; and Figs. 7 and 8—Clearance diagrams for platforms.

Mr. President, I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 4—Compilation of the Railroad Clearance Requirements of the Various States.

Chairman Dahl: The usual tabulation of clearance requirements is not presented this year, but a completely new and revised tabulation will be presented a year hence. All the various laws and regulations are being reviewed. This is a big assignment, and I am happy to say that considerable progress was made during the last year by the subcommittee under the direction of J. F. Smith, inspector, Illinois Central Railroad, the subcommittee chairman. Mr. Smith, will you please rise.

Assignment 5—Clearance Allowances to Provide for Vertical and Horizontal Movements of Equipment Due to Lateral Play, Wear and Spring Deflection, Collaborating with the Mechanical Division, AAR.

Chairman Dahl: The report on Assignment 5 will be presented by the subcommittee chairman, E. E. Mills, design draftsman, Pennsylvania Railroad.

E. E. Mills: Mr. President, Mr. Chairman, members of the Association and guests:

Your committee submits, for approval as recommended practice and publication in the Manual, a method of determining clearance allowances for horizontal movement of passenger cars, which has been concurred in by the Mechanical Division.

Mr. President, I move that this report be adopted and inserted in the Manual in a new Miscellaneous Part for Chapter 28.

[The motion was duly seconded, was put to a vote, and carried.]

CHAIRMAN DAHL: Thank you, Mr. Mills.

The Manual material just adopted, involving passenger equipment, was the result of field tests on eight different cars of six railroads. The need for similar information about freight cars was the incentive for similar tests under this assignment of freight equipment, in cooperation with the Joint Committee on Relation Between Track and Equipment, AAR.

Tests on freight cars were made on the Lackawanna Railroad in 1955, and reported in the 1958 Proceedings. They included cars with center-of-gravity heights from 70 to 100 in under full lading, with long- and short-travel springs, for various speeds on straight and curved track. Supplementary tests with the same class of cars were made last Fall with 70- and 85-in center-of-gravity heights, with full loads, one-half loads, and empty. The latter tests are being analyzed and will be reported later. However, the committee thought that you would be interested in seeing something about the running of the test trains, and a 10-min film has been prepared covering both sets of tests.

We wish here to acknowledge the great aid given to this program by the Lackawanna Railroad through G. A. Phillips, retired chief engineer, and Robert F. Bush, chief engineer, in furnishing facilities and supervision and paying for the test train in 1955.

We are happy to have with us to give the commentary on the film, Randon Ferguson, electrical engineer, AAR, who was in charge of the tests. Mr. Ferguson.

[The film was then shown, with the following commentary by Mr. Ferguson]:

RANDON FERGUSON: The cars were loaded with scrap rail so that the rail could be moved up and down in the timber framing you see in the cars and blocked up to give the desired center-of-gravity heights. The rails were yoked together in bundles for each loading so they could be handled as a unit in changing the loading from one center-of-gravity height to another. This is one of the periods where we were changing the loading height. The bundle you see there is timbers for blocking up under the rails. Two gantry cranes were available when necessary to change the load. The two cranes are lifting out the rails now to set them aside while the framing supports are moved. The support in the framing will be changed so that the rails can be put in at a different position for a different height of center of gravity. These pictures were taken during the 1955 test. That is the 65-ton loading of rails.

Test Train of Instrument Car and Two Test Cars—The locomotive was a high-speed unit capable of running 80 mph. There you see the instrument car. One of these test cars had short-travel springs, 1⅝-in travel and the other car had long-travel springs, 3$\frac{11}{16}$-in travel. Here the test train is out on the right-of-way for a test run. The test run was 35 miles from Hoboken to Denville, N. J.

Truck of the Test Car, Spring Travel 3⅝ in—This is the truck with the long-travel springs. Longer travel springs will, of course, give more roll or swaying and require more clearance.

Spring Travel 1⅝ in—This is the standard AAR old-type spring. It is stiffer and does not give as good a ride condition, especially vertically.

View of Cars During Test Run—All the sway was not in the car; some of it was in the photographer. This run was pretty fast, probably around 50–60 mph.

Attaching Accelerometers to the Test Cars—That is the upper lateral accelerometer being attached to the framework. The basic pickups were accelerometers, and the accel-

eration was integrated twice to give the absolute displacement of that point in space. The acceleration was also recorded. These are the lower accelerometer pickups where we had both a lateral and vertical pickup. Gyros measured the car body roll.

Electronic Instruments and Recorders—This is taken inside the instrument car, and you see the various amplifying integrating and recording instruments that were used for the test. This is the speed recorder, and the oscilloscope that recorded the resultant of the vertical and lateral displacement. The oscillograph is a pen-writing type instrument that has six channels. You can see the variations in some of the records. The train is running along pretty fast I would judge. The light was none too good in there because we did not have artificial illumination.

Static Lean Tests, Tangent and Curve—We took static lean tests on three curves with elevations of approximately 2, 4 and 6 in to correlate the dynamic results with the static action, with the idea that dynamic tests would not be necessary for other types of cars or conditions. These lean tests were made by means of levels, plumb lines and scales. There you see your committee chairman at work. Here is another view of the lean tests. Lean tests were made for each test condition. The man in the white shirt was Charlie Kaier from the DL&W engineering department, who helped us greatly in the first set of tests. He died about a year ago.

Turning Train at End of Run—The train was turned at the end of the run on a wye at Denville so we could run the equipment in the same relative direction going back. This gives you a good view of the train. We had to have some pretty husky timbers in there to support 65 tons of rail. That is one of the lower center of gravity loads.

Chairman Dahl: Thank you, Mr. Ferguson. It is evident that a great deal of time and effort was expended by you and your associates and the Lackawanna Railroad in making these tests. We feel confident that the results will be just as gratifying as the results of the passenger-car tests. We will be looking forward to your further report. I might say at this time that efforts are being made to arrange similar tests on piggyback loads.

Assignment 6—Compilation in Table Form of Offsets for Overhanging Loads on Curves.

Chairman Dahl: This is a new assignment, and the long and tedious work of compiling the offsets is nearing completion under the direction of W. P. Kobat, draftsman, Atchison, Topeka & Santa Fe Railway, the subcommittee chairman. Mr. Kobat, will you please rise.

Assignment 7—Methods of Measuring High and Wide Shipments.

Chairman Dahl: Your committee this year is presenting as information a drawing showing both fixed and mobile measuring devices for checking high and wide loads. The drawing is being submitted to the Mechanical Division for collaboration with the view of developing a mutually satisfactory drawing for publication in the Manual. R. A. Skooglun, chief draftsman, Northern Pacific Railway, is the subcommittee chairman. However, Mr. Skooglun was unable to be here today.

With this convention, I have completed my term of office as chairman of Committee 28. I wish to thank the members of the committee, Mr. Howard and his staff, and Mr. Magee and Mr. Ferguson of the AAR research staff, for the help and cooperation that has been extended to me during my term of office. I would now like to

introduce the incoming chairman, J. G. Greenlee, clearance engineer, Pennsylvania Railroad. Mr. Greenlee, will you please rise. I would also like to introduce the incoming vice chairman, R. L. Williams, special engineer, Illinois Central Railroad. Mr. Williams, will you please rise.

Mr. President, this concludes the report of Committee 28.

President Woolford: Thank you, Mr. Dahl, for the interesting and informative reports presented by your committee, and for the Manual recommendations which your committee has presented in order that the recommended practices of this Association with respect to clearances may represent the best thinking of this Association. And thank you, Mr. Ferguson, for the interesting presentation which you have made covering the freight car clearance tests made on the Lackawanna.

Mr. Dahl, on behalf of the Association, I want to thank you for the able manner in which you have directed the efforts of your committee for the past three years in this important matter of clearances, and for the close collaboration which your committee has maintained in these matters with other interested groups of our Association and the AAR.

As you lay down your responsibilities, we are pleased to welcome as the new chairman of Committee 28, Mr. Greenlee, and as the new vice-chairman of your committee, Mr. Williams. We are satisfied that under their direction the good work of your committee will continue in the years immediately ahead. Your committee is now excused with the thanks of the Association

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President Woolford: We will now interrupt for a few moments the consideration of our physical and material problems as engineers and turn our attention to the more humanistic aspect of engineers and engineering. Like most other technical associations and societies, our Association concerns itself primarily with the technical phases of our profession, the application of the arts and sciences to our problems. That is, no doubt, as it should be. But there is another important aspect of engineers and engineering which cannot be neglected if we are to have a sound, respected, and growing profession. I refer to the professional, social and economic interests of the professional engineer himself. In this field, one national society stands out and speaks freely and forcefully. This is the National Society of Professional Engineers, with a membership of more than 50,000.

Our next speaker is none other than the current president of that Society, Harold A. Mosher, who is associate director of engineering of the Eastman Kodak Company at Kodak Park Works, Rochester, N. Y.

Mr. Mosher is a graduate of Occidental College at Los Angeles, in that wonderful State of California, and prior to his present position was associated with Bell Telephone Laboratories in New York City and Consolidated Film Industries in New Jersey. He has served as president of the Monroe County Chapter of the New York State Society of Professional Engineers and has been a director of both the State and National Societies. He is also a member of the American Society of Mechanical Engineers and the American Society of Air Conditioning and Ventilating Engineers.

Through his practical experience and various society affiliations, Mr. Mosher knows both aspects of the engineering picture, the practical and the personal. Without further encroachment on his time, I want to present him to you. He will address us under the subject, "The Engineering Profession Comes of Age." Mr. Harold A. Mosher.

The Engineering Profession Comes of Age

By Harold A. Mosher

President, National Society of Professional Engineers

Thank you, President Woolford, other officers of the American Railway Engineering Association, members and guests:

It is, of course, very much an honor for me to be your guest and have a part in your meetings here today. Your hospitality has been most gracious, and it is a pleasure for me to bring you the greetings of the more than 53,000 members of the National Society of Professional Engineers and their best wishes for a most successful and fruitful meeting. As I have listened to your program thus far and have looked at your schedule for the remaining part of your convention, it seems to me that the one very unmistakable fact is that this is a hard-working group of people.

As a matter of fact, it reminds me a little bit of the man who was a participant in various engineering conventions. His wife was more than a little curious as to just what went on, but every time she would question him about it, he would say, "Oh, it's just hard work, meetings, committees. We never have any fun." As a matter of fact, he was telling her about a meeting that was coming up and she said, "Well, don't you have any social events at all?"

"Well, yes," he said, "on Thursday night there is to be a kind of costume party there, if you want to make me a costume."

So she pulled together a Mickey Mouse costume for him and sent him on his way.

Come Thursday morning, however, she grabbed a plane and arrived and quietly registered at the hotel, and she showed up at the party herself in a Minnie Mouse costume. Sure enough, Mickey was already there. He was the life of the party and really living it up. Well, what could be more natural than for Mickey Mouse to dance with Minnie Mouse? And what could be more natural than that when the evening was over, perhaps Mickey Mouse should suggest that she might like to come up to his room for a nightcap and maybe look at his etchings, or what have you!

But the next morning, the wife left early, and returned home in time to precede the arrival of her husband. When he came back, she very coyly greeted him. She said, "Well, dear, did you have any fun at the convention?"

"No," he said, "it was just hard work, meetings, committees and what have you."

She said, "Well, how about that masquerade party? Didn't you have any fun at that?"

He said, "No, I couldn't even go, I had a committee meeting; but, you know, the guy who borrowed my costume, he really had a ball." [Laughter]

There is another story there. That grand old man of engineering, Dean Daugherty, who is now at Penn State University, tells the story a little bit differently. This guy also went to quite a few conventions and everywhere he went, he took his wife along with him and, as a matter of fact, it was so unusual that it sort of irked the curiosity of his neighbors and they finally got him aside one day and asked him, "How come?"

"Well," he said, "it is really not too unusual. As you know, my wife ain't no beauty; in fact, I doubt very much if she was ever even invited to enter a beauty contest and, you know, somehow or other I would just rather take her with me than kiss her good-bye."

Perhaps one more story before I get into my paper: I know that all of you fellows come to such a meeting as this by way of the railroads. Of course, you would. But I thought you might be interested in a little story about how the other half lives, those

people who ride the planes. It seems that there was a big plane right over Chicago, in fact, and their landing conditions were not ideal. They had been stacked up here for a couple of hours and, as usual, the passengers began to get a little bit restive; there were rumors floating around that the landing gear couldn't be lowered, that they were running out of gas, that they were in deep trouble. Even the stewardess finally became a little bit concerned about it and she picked out a very distinguished-looking man, such as Mr. Woolford here, and said to him, "Some of the passengers are becoming nervous and worried; you have got to do something. Why don't you say a prayer?"

The man said, "Why, I'm no pastor; I don't even know how to start a prayer."

She said, "Well, you have got to do something. Do something religious."

So he took up a collection.

Well, your officers have very kindly asked me to come here today and to think together with you something about the opportunities for professional growth of our engineering family, both as individuals and as a group, and I am of course delighted to do so.

Perhaps it is appropriate for me to start by confessing that I know little or nothing about railroading. My closest approach is the usual adult fascination with the electric train set, ostensibly purchased as a Christmas gift for a 5-year-old daughter.

However, even an amateur will find certain of the data in the 1959 Yearbook of Railroad Information of interest. It *is* interesting that 25 years ago Class I American railroads carried more than two-thirds of the total U. S. ton-miles of freight, the very life line of American business and industry, and a similar proportion of passenger traffic. It is of *concern* to the amateur, that these proportions have today fallen to less than half for ton-miles of freight carried, and to less than one-third for passenger traffic. The amateur finds it *hopeful* that the total actual volume of freight carried by railroads has increased, with growth in American economy, by about 50 percent during the same quarter-century, even though passenger traffic is now at about the same level as it was in 1935. The amateur finds it *impressive,* too, that the important "ton-miles per train-hour" criteria for efficiency of freight-train operation has steadily increased, setting a new record in each of the last 12 years. It is equally impressive that railroad managements, in the face of increasing, and often unfairly subsidized competition, has been willing to invest more than a billion dollars per year, on the average, since World War II, in capital expenditures to finance these improvements.

Most important, the amateur cannot help being aware of the vital, irreplaceable role which American railroads must play in assuring the future economic well-being of our country, as well as its military defense in any future emergency. It *must* be the concern of every American that your industry remain strong, vital, and economically sound.

This vitality will of course be affected by many factors, including among many others, continuing sound management, and public confidence which will insure adequate financing. However, it seems to us that it will also be determined, in an important degree, by the ability of the industry to continually develop and maintain a staff of able, creative, scientifically-trained professional engineers, capable of accepting the "existing challenges" and continuing and even accelerating the trend toward more flexible, more efficient, lower cost transportation.

Developing such a staff, too, has many facets. Like every other industry, in the exploding technology of our times, American railroads will be concerned that every opportunity is provided for engineers, current graduates as well as more experienced ones, to strengthen, broaden, and deepen their engineering education. Leading engineer-

ing educators and practicing engineers are, of course, aware of this problem, and good progress is being made. Even more emphasis is needed, however, particularly in the fields of curriculum reform, wider availability of graduate study programs, and improved teaching techniques.

Another area, often overlooked however, is that of opportunity for professional growth of our engineering family. Does that seem like kind of an empty-sounding phrase to you? It shouldn't, for in my observation, leading practicing engineers, leading engineering executives in industries all over these United States of ours, are becoming more and more aware of the need for stretching out the areas of responsibility in which engineers will think and bring their high skills to bear. More and more they are recognizing that it is not possible for an engineer to practice his high skills in a cloistered corner, where he is concerned only with formulas and calculations of one sort or another. More and more they are recognizing that the most effective role of the engineer is in the area of analyzing, of decision-making, of direction-determining, and that the direction which he provides will determine the economic health, the economic welfare and strength of the organization to which he belongs.

Perhaps one illustration of this trend and the thinking of engineering leaders is the action taken a couple of years ago by leading industrial people in this country, top-notch officers of leading industries, in joining together to advise the leadership of our National Society of Professional Engineers in those areas where their engineering people now on their staffs could be encouraged to think more broadly, to accept wider responsibility, to go that second mile beyond the first mile, to think together with the leadership of NSPE as to how best the climate could be provided for that kind of professional growth.

As another illustration, Gen. A. M. Minton of the Air Corps recently said that he regards the acquisition of a strong professional attitude by engineers to be a most important factor in America's battle for military survival. Gen. Minton is apparently convinced that such an attitude is necessary to provide increased motivation for more creative, fruitful contributions by these already technically trained people.

Unfortunately this professional attitude is not easy to generate, in a short time, in a large family of technical people with widely diversified training and interests. It is particularly not easy for engineers, a relatively young, professionally unsophisticated group. Perhaps that youthfulness and relative immaturity is best indicated when we realize that 90 percent of the engineers who have *ever* practiced, are practicing now, and that more than half of the qualified engineers in America today received their first degree since World War II.

Certainly an important first step in the direction of that professional growth is to encourage the registration of all qualified engineers. Granting at the outset that the professional attitude will not be acquired through laws, or by designated titles given by business management, registration is none-the-less important, for it precludes the necessity for the engineer to tread that narrow path between illegal practice on the one hand, or demoting his efforts, in his own mind at least, to a sub-professional, technician-type activity on the other. Registration of engineers must be accepted as a fact of life in our times; laws require it in every state and territory, and the N.C.S.B.E.E. now estimates that two-thirds of all engineers who are *qualified* for registration, *are* already registered and this proportion is growing rapidly. It is the only accepted *legal* proof of capability.

Becoming registered, however, is only the first step. The *whole* engineer, who aspires to contribute to his employer, or to his clients, or to society at his highest level of capabilities, will aline himself with his fellow engineers in group activity; in the tech-

nical society of his specialty, such as AREA. Yes, but also in his professional society. He must be concerned with policing his profession, protecting the public and his employer against the imposter who represents himself as an engineer. As a member of the group, he must be concerned with seeking proper legislation such as, for one example, that opposing unionization.

It has been estimated the engineering profession has 35 different publics in which we must develop an image, a picture, of what we would like those people to think of us. He must be alert to the need for interpreting to his many "publics" the aims and objectives of the whole engineering family, all to the end that his engineering profession will be as strong as it needs to be to meet every demand that society may make upon it, either for the economic well being, or the military defense, of the total community.

I know that most of you will recognize this latter as the area of activity of your National Society of Professional Engineers. I firmly believe that this should be a part of the experience of every engineer, for here, literally, is the fountain head where professional problems of engineers of every discipline or geographical location are weighed, debated, and action decided upon; a man cannot be a part of it, in however small measure, without some of it becoming a part of him.

I wish it were possible for me to take the time to tell you of the many programs of your NSPE; in such fields as scholarship promotion, engineering preparation, ethical practices, student training in professional attitudes, the inherent contradiction of unionization with professionalism, and scores of others.

If I were to try to go through all these programs with you, I am sure you would find yourself in the position of my young ten-year-old, red-headed daughter who recently received a gift from grandma. She was in the process of writing a thank you note and she said, "Dear Grandma: Thank you very, very much for the lovely book you sent me all about penguins. I have read it from cover to cover. It told me more about penguins than I cared to know."

It must suffice then, to remind you that all these scores of programs are carefully conceived and implemented by leading engineers from every discipline and from every state and territory. They are a synthesis, a distillation of the grass-roots thinking of the more than 53,000 individual members of NSPE, who are, in turn, members, generating action, in the 51 state societies, and the more than 400 local, community chapters. Each one of these programs is aimed at providing the opportunity for the professional growth which we seek.

Yes, it seems to me that our engineering profession is "coming of age". Each of us can be a part of that growth from adolescence, by contributing a small part of his time and his high skills to those programs and organizations which provide the individual engineer opportunities for growth, enabling the profession to build into itself the strength and idealism which will merit a great destiny.

A quotation over the entrance to the Archives Building in Washington, D. C., reads "All Past Is Prologue." There is a story of a visitor to Washington asking his cab driver what the quotation meant. The driver's reply was "I guess it means, brother, you ain't seen nothing yet." So it is with the potential contributions to American life of our young, vigorous, vital, unsophisticated engineering profession: the curtain hasn't yet gone up on the first act! Ours individually, is the responsibility for action, to be certain that engineers of future generations, as well as our own, recognize and accept the opportunities for their professional as well as technical growth, so necessary if we are to accept the thrilling challenge of our times. [Applause]

President Woolford: Thank you, Mr. Mosher. We deeply appreciate your having addressed our convention. You have caused many of us to raise our sights above our daily problems, important as they are, to a realization that we, as engineers, are part of a sound and respected profession, which must be continued as such. Your Society is doing a magnificent job to this end. Thank you again for meeting with and addressing us.

For the next feature of our program, which deals with a highly competitive form of transportation but with which there are opportunities for the railroads to cooperate to their advantage, we have gone all the way to the Pacific Coast to secure the best-qualified man to speak to us. To properly present him to us. I have asked one of our members who knows and who has worked with him to do this, W. M. Jaekle, chief engineer of the Southern Pacific Company, and a director of the AREA. Mr. Jaekle, I will appreciate your escorting our next speaker to the platform and introducing him to us at this time.

W. M. Jaekle: President Woolford, ladies, guests, members of the American Railway Engineering Association:

It was some five years ago that the Southern Pacific Company determined that a fourth mode of transportation was necessary to supplement its rail, truck and piggyback operation. This was the pipeline transportation of petroleum products.

To operate, maintain and manage its proposed pipeline, competent and experienced engineers, of course, were necessary. As the first chief engineer of a pipeline company, William T. Eskew, Jr., was selected. A mechanical engineering graduate of Duke University, Bill Eskew came to us with eight years of experience with Plantation Pipeline Company as a supervising engineer and division engineer. During the five years that Bill has been chief engineer, our pipeline company has shown a very satisfactory net profit. This is a desirable thing. As a result of his part in this net profit, Bill Eskew was only recently promoted to the position of assistant general manager, which means that he is the assistant chief operating officer of our pipeline company. I am sure that you will be interested in what Bill Eskew has to tell you of the Southern Pacific pipeline story.

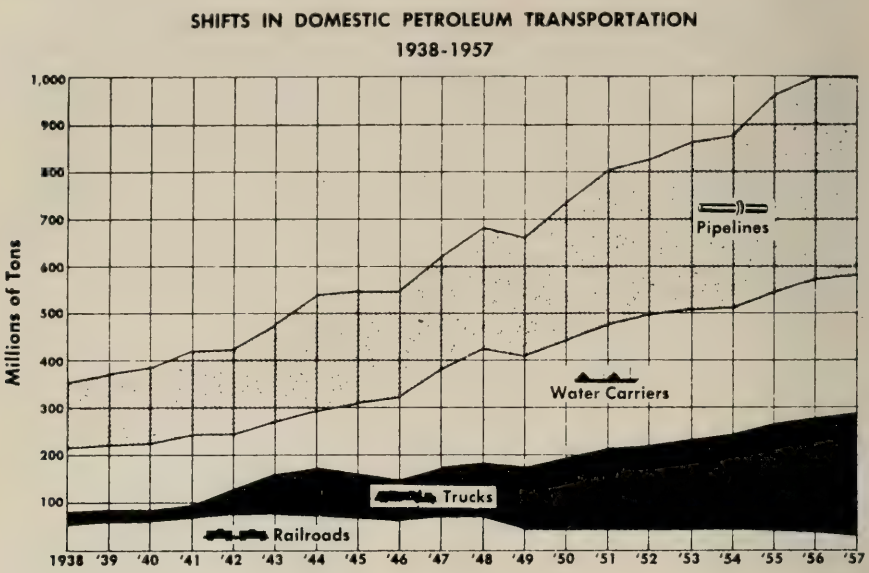
Oil Pipelines on Railroad Rights-of-Way

By W. T. Eskew, Jr.

Assistant General Manager, Southern Pacific Pipe Lines, Inc.

During the past 20 years, 86,000 miles of petroleum pipelines have been constructed in the United States. With this tremendous growth in the pipeline industry, and especially since our company entered the pipeline business and several other railroads are considering doing the same, President Woolford felt that this group would be interested in the Southern Pacific Pipe Lines story. In relating this story I will try to tell you a little bit about why we entered the pipeline business, how our system was built, and how it operates. Also, this will be followed by a short question and answer period during which I will be glad to receive any questions which you may have from the floor.

In 1938, 354 million tons of crude and petroleum products were transported in the United States. By 1958 this had increased to over 1 billion tons. During 1958 pipelines alone moved 441 million tons, or more than was transported by all carriers during 1938. This is approximately 43 percent of the total transportation. As you will notice, transportation by railroad has declined from 16 percent in 1938 to slightly more than 3 per-



cent in 1957. With this shift in domestic petroleum transportation, it is obvious that for steady long-distance transportation of large volumes, the economies of pipeline transportation are more favorable than most other means.

By 1954 consumption of petroleum products in the Tucson–Phoenix area of Arizona and in the Imperial Valley of California had grown to an extent warranting pipeline transportation. Certain oil company refineries were located in Los Angeles and others in the El Paso area, most of which were interested in serving the Arizona market. The Southern Pacific Company, whose transcontinental rail lines interconnected these points, was transporting a substantial part of these volumes by tank car. Tank trucks were also moving substantial volumes. Construction of the pipeline system by some party or parties was inevitable. In fact, several oil companies were making studies of the area for pipeline purposes at that time. The Southern Pacific Company management, believing that the company should be an integrated transportation company able to offer the shipping public the most efficient method of transportation, began to seriously consider construction of a pipeline. Of course, the hard fact that tank car movements would be lost to a pipeline was also a factor. Our company reasoned that the loss of this business was inevitable, so it was preferable to lose it to its own pipeline rather than to some other company. The fact that our railroad had much of the needed right of way was also an important consideration.

The Stanford Research Institute was engaged to conduct a market analysis. Quantities of product which could be expected to move by pipeline immediately and in the future were determined. At the same time, a reliable pipeline engineering firm was retained to accomplish the necessary economic study. Even with a 40 percent cut in tariff between Los Angeles and Phoenix, the payout looked good. So in February of 1955 the decision was reached to construct a pipeline system. The engineering firm was given the job of planning and supervising the construction, with work beginning immediately. It was our objective to have the system in complete operation by the end of 1955. The

pipeline system proposed and constructed actually comprised two separate pipelines. One would connect Los Angeles refineries with Phoenix, Ariz., including intermediate delivery terminals at Colton and Niland, Calif. The other would connect El Paso refineries with the Tucson and Phoenix areas. The proposed system would serve all qualified shippers as a common carrier. At this time a separate subsidiary company was formed known as Southern Pacific Pipe Lines, Inc., to own and operate the pipeline system.

As with other major product pipeline systems, it was proposed to operate a segregated batch system; that is, each shipper's product would be segregated within the system.

For pipeline operation, various shipper companies must have facilities for getting their product into the pipeline system, and then must have adequate tankage at the delivery terminals for receiving such product. Most pipeline companies provide tankage at the originating stations; however, in our particular case it was decided to minimize such tankage and, for the most part, oil companies pump directly into our system.

Since tankage and truck loading facilities at the various terminals would represent a considerable investment for each shipper, we offered the oil companies several different plans which would better enable them to use our system. Our Plan "A" is a plan whereby the shipper builds and operates his own terminal facilities. Five of our shippers selected this plan. Our Plan "B" was one in which the shipper bulids and operates his tankage and terminal facilities, but the pipeline company constructs tank lines to his tankage. One shipper selected this plan. Our Plan "C" was one whereby the pipeline company builds and operates terminal tankage for a shipper, and the shipper owns and operates his own truck loading rack facilities. One shipper selected this plan. Our Plan "D" was one whereby the pipeline company builds and operates tankage and terminal facilities for the shipper. Four shippers selected this plan.

Several other modifications of these plans have been adopted since our original construction; however, these are the basic plans still in effect.

In April of 1955 the Air Force finalized its interest in securing pipeline deliveries at four of its major air bases in Arizona and California. This additional volume, of course, increased the importance of and the need for a pipeline in the Arizona area.

After preliminary survey, it was decided that approximately 60 percent of our original pipeline system could be economically located on railroad right-of-way. Since this pipeline system was to cost approximately $25,000 per mile and since railroads are confronted with grade restrictions, it was sometimes more economical to leave the railroad right-of-way and procure additional right-of-way from private owners in order to effect a shorter system.

Our originating pump station on the Los Angeles to Phoenix system is located at Watson, Calif., which is a point conveniently situated in relation to the several oil company refineries which it serves. A 16-in line extends 62 miles from Watson eastward to Colton, Calif. This line was routed to pass through the Air Force Petroleum Storage Depot at Norwalk, Calif. Air Force product is injected at this point. At Colton, a point essentially situated to serve the fast-growing Riverside–San Bernardino area, a combination delivery terminal and main-line pump station was established. Storage tankage and pumping facilities were also provided at this point for further handling of aviation products through a 15-mile-long 6-in lateral line extending from Colton to March Air Force Base near Riverside. A 12-in line extends 360 miles from Colton to Phoenix by way of Niland, Calif. and Yuma, Ariz. A delivery terminal is also located at Niland, and there has since been added at Yuma a 9-mile-long 6-in lateral line to serve the Marine Corps Auxiliary Air Station at that location. A 30-mile 6-in lateral was also

recently added from Niland to Imperial, Calif. for providing delivery and terminal facilities in the fast-growing Imperial Valley area. The stream is pumped from Colton to Phoenix without intermediate booster pumping. Design capacity of the Watson to Colton line is 53,000 barrels per day on gasoline, and the 12-inch line between Colton and Phoenix is 37,000 barrels per day.

The originating pump station on the El Paso to Phoenix system is situated convenient to the refineries which it serves in the Texas area. An 8-in line extends 420 miles to Phoenix by way of Lordsburg, N. M., and Tucson, Ariz. A delivery terminal at Tucson provides facilities for various commercial shippers as well as tankage and pumping facilities to handle military products to serve Davis–Monthan Air Force Base located four miles away. The original capacity of this line was 14,500 barrels per day on gasoline; however, before the first full year of operation was complete, the line was filled to capacity. It was necessary to add four remote-controlled booster stations between El Paso and Tucson to increase the capacity of this line to 36,000 barrels per day. These four new stations are controlled by our Products Movement Department in Los Angeles.

Phoenix is the end point terminal for both lines, and a large group of oil company terminals have been established at that location. Some oil companies are connected to receive product from El Paso as well as Los Angeles, whereas others are restricted to deliveries from one system or the other. Quality-control tankage and pumping facilities were also provided at Phoenix for further shipment of military product to Luke Air Force Base through an 18-mile-long 6-in lateral, and through a 140-mile-long 6-in lateral to supply Williams and Davis–Monthan Air Force Bases.

As previously mentioned, approximately 60 percent of this system is located on railroad right-of-way; however, significant amounts are located in city streets, on county roads, and on private lands. The first 30 miles of 16-in line in the Los Angeles Basin is situated in all four categories. Conventional pipeline easements were taken across private lands. Franchises for use of city and county roads were obtained. In planning our line on railroad right-of-way, only a few special measures were necessary. We made every attempt possible to locate the pipeline more than 50 ft away from the main-line track. At this distance, only 30 in of cover is maintained. When it was not possible to stay 50 ft away from the tracks, we increased the depth of cover from 30 to 60 in. In planning the most economical location, it was necessary to switch back and forth under the tracks, and at these points the line was cased in accordance with conventional AREA standards. In other locations where the railroad was located in narrow cuts or fills, it was necessary to leave the railroad right-of-way completely for economical construction.

In taking a quick look at the hydraulics of this system, our Watson Station is slightly above sea level, Colton is at an elevation of 1000 ft, Niland is at an elevation of 140 ft below sea level, and Phoenix is at an elevation of 1100 ft. The line between Colton and Phoenix also crosses a summit with an elevation of 2700 ft. From El Paso at an elevation of 3800, the line passes over Apache Pass at an elevation of 5400, drops down to Tucson at an elevation of 2600, and on into Phoenix at 1100. These topographic conditions, together with considerations for the most economical sizes of lines, required the use of high operating pressures. For example, on our 16-in line we operate at a maximum pressure of 600 psi, on our 12-in line 1320 psi, our 8-in line 1440 psi, and on the 6-in lines up to 1660 psi. To minimize required steel tonnage, high-test line pipe was used with yield strengths of 42,000 psi on the seamless pipe and 46,000 psi on the electric welded pipe. Wall thickness of the pipe varied from ½ to 7/32 in, depending on the pressure conditions for that particular location.

To prevent or at least to minimize corrosion, all of the lines were coated. In the congested Los Angeles area where corrosion leaks would be critical, we used somastic coating, which is a very effective and tough asphalt-asbestos coating. All other lines were coated over the ditch with hot asphalt enamel together with glass and felt wrap.

Block gate valves were proposed and installed at approximate 20-mile intervals for emergency and maintenance purposes. Crossings of six major waterways were made with pipeline suspension bridges. These include the San Pedro River in New Mexico, the Colorado River near Yuma, and several other important irrigation canals. The largest of these spans is across the San Pedro River, with an unsupported span of 1020 ft.

Prior to placing the lines in operation, all were given exceptionally high hydrostatic tests following completion of construction to assure a tight line after products were put into it. In general, the test pressure was set at 95 percent of the yield point of the pipe based on its nominal wall thickness.

At our Watson Pump Station, four major refineries located 2 to 12 miles away inject directly into our incoming manifold header. Their pumping facilities have been designed to match the characteristics of our main-line pumps so that product normally may be received directly into suction without going to tankage.

Three floating roof tanks with a capacity of 109,000 barrels are provided should any operational difficulty be experienced by the refinery or the pipeline. Also, when a refinery is not able to match the pipeline rate, the batch can be accumulated in tankage prior to being pumped out through our main-line system.

From the incoming manifold the product is taken through water filter separators containing prepacked excelsior, then through 40-mesh strainers and positive displacement meters.

In this regard, all product is metered into the system and we take custody of it at that point. As the product leaves our system at various delivery terminals along the line, it is likewise again metered and delivered to the shipper on the basis of a meter ticket.

These meters are very carefully calibrated at regular intervals by the use of a prover tank. At Watson Station this prover tank is 2000 gal in capacity and has been calibrated with Bureau of Standards test measures. Therefore, its volume is very accurate. By comparing the meter reading with the very accurate volume determination in the prover tank, a meter factor adjusted to 60 deg is established. In this way extreme accuracy is established with our meters.

From the meters the product enters our main-line electric-driven centrifugal pumping units. At Watson three 300-hp units are installed, two of which operate in parallel, and the third serves as a standby spare. All of these units are horizontal centrifugal units equipped with mechanical seals. From the discharge of the pumps the product passes through a station discharge control valve and thence through the outgoing scraper trap.

Scraper traps were planned for all stations and terminals for injecting and receiving scrapers to assist with the internal corrosion control of the system. Scrapers, commonly called "pigs" in the pipeline industry, are shot at regular intervals and are forced along by the flow of the product, cleaning the interior walls of the pipe. The maximum distance that one scraper is run through a line is approximately 150 miles. The station discharge control valve is a pilot-operated pneumatic valve equipped with two set points with over-riding features. One set point is set for low suction pressure control, and one is set for main-line pressure control. Normally, the main-line pressure will be the govern-

ing factor; however, if the suction pressure should fall below a given set point, the low suction pressure control will over-ride the main-line pressure control and cause the valve to pinch down.

At Watson Station, as well as at all main and lateral line stations, transformers, electric metering facilities, circuit breakers, and motor starters are housed in metal-clad outdoor-type cabinets. All power and lighting current is metered at 2300 v. Main-line motor starters at Watson are of the across-the-line type, having 240-v A-C control voltage. All underground electrical runs are in galvanized rigid conduit, which conduit is enclosed in a red-colored concrete envelope where, if possible, all conduits running into the same area are grouped in a single envelope.

Our buildings at Watson Station consist of a roof shelter over the main-line units, meters, strainers, separators, and associated equipment. A small control building having an office for the station chief, a control room, toilet and locker room, equipment room, and a laboratory are also located here. A small metal building is provided for storage of fire-fighting foam and miscellaneous station materials. The architecture of the control building and pump shelter at Watson as well as at all other locations is based on a modern motif. The shelter is constructed with a structural steel frame, flat roof, and aluminum side louvers. It is provided with an overhead crane traveling the length of the building which is used for maintenance purposes and is capable of lifting a single main-line pump unit. The control building is constructed of buff-colored brick, having a flat roof with wide overhang and aluminum louvers. Heating and air conditioning for this building are provided with a heat pump combination unit.

The control room is really the nerve center for the entire pump station since it contains the control console and panel. From this point the station operator can start and stop the booster pumps as well as the main-line units. He can control 14 of the 18 motorized valves at that location. He can control the set point of the station discharge control valve and observe pump case pressure, main-line pressure, incoming pressure, and ampere load on each main-line motor. The control panel also records the temperature and specific gravity of the product being pumped, the suction pressure, and the line discharge pressure. The control panel is also provided with an alarm panel which would indicate by lights low suction pressure on each unit, low main-line discharge pressure, high main-line discharge pressure, high sump level, high and low tank levels, high motor bearing temperature, high pump bearing temperature, and high pump case temperature.

All of our pump stations are specifically designed to safely protect equipment; that is, the main-line units will automatically shut down when the suction pressure is too low or the discharge pressure too high, when the bearing temperatures on the pumps or motors are too high, when the case temperature on the pump is too high, or when a low instrument air pressure condition exists. The alarm panel, in addition to having indicating lights, also incorporates the use of an audio buzzer system in the control room itself and a loud sounding horn for the outside area. When something goes wrong and an alarm condition exists, the buzzer and horn sound, and the panel indicates the existing condition. When the alarm condition is corrected, the indicating light will automatically reset itself.

Considerable extensive hand sampling of product into the system is maintained by the station operator; that is, samples of each product are caught as the product enters the system, and this sample is compared with the product as it is delivered from the system at a particular terminal. We maintain a quality control laboratory for this system at Phoenix, and a portion of each input sample is forwarded to our control

laboratory at that point for rechecking with each delivery. In this way we always have a definite record indicating the quality of the product entering and leaving the system.

Our Phoenix delivery terminal is typical. Duplicate facilities are provided for both the 12-in and 8-in incoming lines from Los Angeles and El Paso, respectively. These consist of water separators, strainers, meters, prover tank, etc. The delivery manifold for the 8-in and 12-in line was placed parallel to each other in order that minimum piping fabrication would be required for a shipper to connect to both manifolds, which will enable him to receive from both Los Angeles and El Paso through one set of delivery lines to his tankage. A control building similar to the one at Watson, a meter shelter, pump shelter, and small utility building comprise the buildings at Phoenix. The main control laboratory for the entire system is located in the Phoenix control building and consists of considerable amounts of equipment, particularly to perform the many rigid tests required in quality control of Government jet fuel and aviation gasoline. This laboratory is staffed by a full-time chemist.

Four shipper companies at Phoenix selected to use our Plan "D" operation; therefore, we own and operate tankage and loading racks for them. At this location we have a total of 15 tanks, and other shipper companies have a total of 24 tanks, giving Phoenix Terminal a capacity of 1,018,790 barrels. At Niland and Tucson, similar delivery facilities have been provided for shippers. Four oil companies receive product at Niland and Imperial, and five oil companies at Tucson.

At several of our pump stations and terminals, adequate water and fire protection facilities were not available. Such being the case, a community water and fire protection system was planned and built. It consists of a deep well, a 5000-barrel water storage tank, and two high-capacity fire pumps discharging into an 8-in pipeline loop around the terminal area. A normal 70-lb pressure is maintained on the loop for domestic water service, and the pumps increase the pressure to 125 lb in case same is needed for fire protection. Necessary dry chemical foam powder, generator hose, etc., are maintained at all locations, and the cost for such a system is shared on a community basis by the pipeline company and its shipper customers.

Since December of 1957 we increased our operations by the startup of a new Richmond, Calif., to Fallon, Nev., line. This system was placed in operation in December of 1957 and is approximately 310 miles long. The line originates in the Richmond area where refineries and marine terminals are located, and extends eastward to Concord where other refineries inject into the system. The line then skirts around the Stockton area, and a delivery terminal was constructed near Sacramento for takeoff of military products. Short lateral lines from this terminal supply Mather and McClellan Air Force Bases with jet fuel and aviation gasoline. The line continues eastward to Roseville, Calif., where a pump station was constructed, then on to Colfax where a second pump station boosts the flow over the Sierras. A maximum elevation of 7200 ft is reached at the summit. The line descends on the eastern side of the Sierras to Reno, Nev., the end point terminal. The close spacing of pump stations is brought about as a result of the extreme change in elevation on this particular line.

Reno Terminal, like Phoenix, consists of commercial terminal facilities and storage and pumping facilities for military jet fuel. A 6-in line originates at Reno and extends 60 miles to the Naval Auxiliary Air Station at Fallon.

The right-of-way, starting in low rolling hills in the Bay Area, passes through sloughs, farm land, hills, and increasingly rough timbered terrain cut by numerous streams, canyons, and ravines. About 7 percent of the route through hard rock required shooting. Most of it was in the solid granite area in or near Donner Summit.

I regret that time does not permit discussing our various pump stations and terminals in more detail; however, I shall be happy to clarify any questions that you might have regarding any of our installations.

Now for a little bit about our operations: As mentioned previously, Southern Pacific Pipe Lines is a fully owned subsidiary of the Southern Pacific Company; however, it is essentially a private company in operation. The general offices are in Los Angeles, and these include the general manager's office, engineering department, products movement department, general and products accounting section, personnel, and materials-handling section. Our pipeline system is divided into three distinct districts. The Western District, with headquarters at Colton, maintains the system from Watson to Phoenix; the Eastern District, with headquarters at El Paso, maintains the system from El Paso to Phoenix; and the Northern District, with headquarters at Roseville, maintains the line from Richmond to Fallon. A district superintendent, head mechanic, head electrician, field engineer, and clerk and stenographer comprise a district office force. In addition, a small maintenance gang consisting of a maintenance foreman and three pipeliners maintains approximately 350 miles each of the pipeline system. Therefore, we have four such maintenance crews. With 1410 miles of product pipeline system in operation, we have 187 employees, 63 of whom are located in the Los Angeles office. As a matter of general information, during original organization experienced pipeline personnel were employed from 28 different oil companies and refineries from most of the states. All have minimum high school education, and most had considerable pipeline experience. The personnel for our new expanded facilities were promoted from within our company.

The actual movement of product through our pipeline system is controlled by our products movement department in Los Angeles. By securing shipper requirements 30 days in advance, a pumping schedule is established. Batches of similar products must be pumped in sequence to minimize intermix problems. Each batch must be coordinated with refinery departments, and deliveries must be coordinated with marketing departments. All of these things, and many others, must be thought about and coordinated in planning pumping schedules. Innumerable factors can arise to change these schedules after they go into effect; therefore, to carry out pumping schedules and to monitor pipeline flow, a full-time scheduling center is maintained. This center is equipped with what is in effect a model of the pipeline system. Product stream is represented by paper tape on which batches are marked to scale. This tape is moved hourly on the basis of hourly meter readings. The position of all batches can be determined at any time, and a terminal can be given an accurate time of arrival for a particular batch change. Hourly meter readings at input and output points relayed by teletype permit the scheduler to determine whether in-flow balances out-flow. A persistent loss indicates a possible leak which will require shutting down and pressure testing the section involved.

As indicated previously, batches are segregated. A shipper's batch is received and the same number of barrels comprising that batch are given back to the shipper at designated delivery points. Batches of regular and premium gasoline, diesel fuel, jet fuel, and aviation gasoline are handled for eleven different shippers. In batching, of course, the big problem is that of intermixing. A certain amount of intermixing does exist and cannot be entirely eliminated. The problem is one of minimizing its effects. This is done in several ways. Pipeline flow rates are carefully kept in the range of turbulent flow. Where flow is stopped, the line fill is kept under high pressure. Our tariff specifies the minimum batch size of 10,000 barrels; therefore, in an 8-in line this would represent approximately 16 miles of pipeline that would be full of that particular

batch. Batches of similar products are placed adjacent to each other. Heart-cuts, or a portion of the batch, are taken off at intermediate takeoff terminals, and the intermixes are taken to Phoenix where they are handled in intermix tanks. Flow rates in our lines range from 1½ to 3 mph, so transit time for batches moving to end point will approximate 10 days. Terminal tanks are sized to hold approximately 3 weeks' supply, and batches are moved through the line on 2-week cycles.

A very close check is maintained on the internal corrosion of our pipe lines. In order to minimize this and maintain a satisfactory "C" factor, we run brush scrapers at two-week intervals and consistently inject a corrosion inhibitor at origin stations. This keeps the interior walls of our pipe smooth; therefore, the pressure loss per mile is reduced to the barest possible minimum.

At pump stations and terminals, all housekeeping and first-order maintenance is done by operating personnel. Higher-order maintenance is performed by specialists from the district headquarters.

Pipeline markers have been installed at intervals of one to two miles. At all road crossings, a permanent cast aluminum disk has been installed. On this disk instructions are printed to call our products movement department collect in case of emergency. These have proven their value several times. Our pipline system is patrolled one a week by an aerial patrol pilot. In addition to determining detrimental conditions to our pipeline, our pilot also observes conditions that might be detrimental to the railroad This, of course, is performed on a contract basis.

After four successful years of operating a major products pipeline on railroad right-of-way, we have found the following advantages:

1. With large volumes and long distances, pipeline operation offers dependable and more economical transportation than can be performed by tank car or tank truck, one of the main reasons being that it is never necessary to return empties to the source of supply and loading and unloading charges are eliminated. Also, our operating ratio is low.
2. Existing railroad right-of-way is extremely valuable to the pipeline company. It affords an excellent way to get through congested areas. Also, railroad right-of-way does not require clearing as a general rule prior to construction, and annual maintenance is practically eliminated since the railroad company performs this work.
3. Pipelines offer good and profitable transportation diversification for railroad capital.
4. Existing communications facilities along the railroad are also used for pipeline communication, thereby resulting in decreased capital and operating costs. Also, as a general rule, highways parallel the railroads, particularly in the western part of the United States; therefore, access to pipeline right-of-way is very good for maintenance purposes. This is certainly not the case in most cross-country pipelines.
5. The operation of a pipeline is performed by pipeline specialists; however, many departments of an existing railroad organization are used to a very good advantage from a construction and operational standpoint, such as freight traffic and tariff departments, accounting, legal, purchasing, claims, and public relations.

Briefly, this is our story. Now if there are any questions from the floor, I shall be glad to do my best to answer them. [Applause]

President Woolford: Thank you, Mr. Eskew, for your interesting and informative address on this important matter, one which is certain to become of increasing importance to the railroads and to involve many of our members. As you know, two of our committees are particularly involved in this matter—our Committee 1—Roadway and Ballast, which at this convention, on Wednesday morning, will present for our consideration Specifications for Pipelines for Conveying Flammable Substances both under railroad tracks and parallel with them on railroad right-of-way, and our Committee 20—Contract Forms, which is vitally interested in the preparation of contractual agreements covering such occupancy of railroad property. I am sure that both of these committees have profited by your talk and would welcome your further collaboration with them in their work. Thank you again for coming here today all the way from Los Angeles to address us.

I might add that I heard Mr. Eskew speak on this subject some time ago and I knew what a wonderful job he could do; so I thought it would be very appropriate if we had him speak on pipelines to us here today.

Discussion on Contract Forms

[For report see pages 393–404.]

[President Woolford presiding.]

President Woolford: Resuming our reports of committees, the next committee to present its report is Committee 20—Contract Forms, of which E. M. Hastings, Jr., wire crossing engineer, system, Chesapeake & Ohio Railway, is chairman. Will Mr. Hastings and the other members of his committee please come to the platform and present their report. Mr. Hastings, we are running a little behind time, so if you can speed up your report and help us to catch up, we will certainly appreciate it. Again, may I ask Mr. Hastings, along with the vice chairman and reporting subcommittee chairmen, to take places here at the main speaker's table as close to the podium as possible. And, once more, I invite discussion from the floor in connection with any or all of the committee reports. Also, Mr. Hastings, I would remind you of the time control box on your right. Mr. Hastings, the microphone is yours.

Chairman E. M. Hastings, Jr.: Thank you, President Woolford. Your Committee on Contract Forms has seven assignments, two of which we are submitting for Manual material this year. On each of the others we are progressing nicely. Our reports will be found in Bulletin 553, beginning on page 393.

Assignment 1—Revision of the Manual.

Chairman Hastings: We have deferred any consideration of Manual revision this year, as we plan a complete review of our chapter in the Manual looking toward its revision in time for reprinting in 1962.

Assignment 2—Form of Lease Covering the Use of Railway Tracks for Storage of Tank Cars Containing Liquefied Petroleum Gases, Anhydrous, Ammonia, and Other Flammable or Dangerous Materials, Collaborating with Fire Protection and Insurance Section, AAR.

Chairman Hastings: The report on Assignment 2 will be given by Subcommittee Chairman W. D. Kirkpatrick, assistant to chief engineer, Missouri Pacific Railroad.

W. D. Kirkpatrick: Mr. President, members of AREA, and guests:

In June 1958, the Board Committee on Assignments gave Committee 20 an assignment to develop a form of lease covering the use of railway tracks for storage of tank

cars containing liquefied petroleum gases, anhydrous ammonia and other flammable or dangerous materials.

Last year your committee presented as information a draft of an agreement to cover this subject and invited suggestions and criticisms thereon. This agreement has been reviewed and revised in accordance with certain suggestions received, and in collaboration with the Fire Protection and Insurance Section, AAR. It is presented at this time with the recommendation that it be adopted and published in the Manual at the end of Part 4, Agreements Covering Track, Chapter 20.

I move that the form of agreement be adopted by the Association and published in the Manual in accordance with the foregoing.

[The motion was duly seconded, was put to a vote, and carried.]

[Vice President E. J. Brown assumed the Chair.]

Assignment 3—Form of Lease Covering Right to Strip-Mine on Railway Miscellaneous Physical Property.

Chairman Hastings: After several years of study, your committee has developed a tentative form of lease under this assignment. It is printed in Bulletin 533, beginning on page 397. We invite your comments and criticisms.

Assignment 6—Form of Agreement for Construction and Maintenance of Highway–Railway Grade Separation Structures for Public Roads.

Chairman Hastings: The report on Assignment 6 will be presented by Subcommittee Chairman J. L. Perrier, division engineer, Chicago & North Western Railway.

J. L. Perrier: Mr. President, members and guests:

Last year your committee submitted as information a draft of a form of agreement for construction and maintenance of highway-railway grade separation structures for public roads, which was published in Vol. 60, 1959, pages 308 and 314, incl., of the Proceedings, and you were asked for comments and criticisms. During the past year, the original draft was reviewed and one minor change made.

It is recommended that the form of agreement as revised be accepted as Manual material, to be published at the end of Part 7, Miscellaneous Agreements, Chapter 20. I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Chairman Hastings: Brief progress statements on Assignments 4, 5 and 7 will be found in Bulletin 553.

I would like to acknowledge the work done this year by Subcommittee Chairmen D. F. Lyons, office engineer, Chicago, South Shore & South Bend Railroad; Clarence Young, assistant engineer, Baltimore & Ohio Railroad; Manuel Garcia, assistant chief engineer, Alton & Southern Railroad; and K. J. Silvey, Area Engineer, Pennsylvania Railroad. Will you gentlemen please stand. Thank you.

Committee 20 takes a great deal of pleasure in bringing you an address on a very challenging subject, "The Relationship Between the Attorney and the Engineer on the Railroad." Our speaker was born in Richmond, Va., educated in McGuire School and Episcopal High School in Alexandria, Va., and the University of Virginia, graduating in law in 1920. He served in the 605th and 29th Engineers in World War I. He was engaged in the private practice of law until 1943, when he joined the legal staff of the Chesapeake & Ohio Railway. His work is concerned chiefly with matters relating to contracts and real estate transactions, which brings him into close contact with the engineering, real estate, industrial and operating departments.

It is a privilege to present to you my personal friend and business associate, the general attorney of the Chesapeake & Ohio, Henry W. Oppenheimer.

The Relationship Between the Attorney and the Engineer on the Railroad

By Henry W. Oppenheimer
General Attorney, Chesapeake & Ohio Railway

Mr. Chairman, members of the committee, honored guests, and gentlemen: I consider it a great honor and privilege to have been invited by your chairman and my good friend and colleague, Ed Hastings, to talk to you on this occasion, however undeserved that honor may be.

In discussing the subject of sermons with a former minister of my church, we agreed that no short sermon was a poor sermon, and while this will hardly qualify as a sermon, I will be guided accordingly. But that reminds me of an experience my father, a doctor of the old school, had just after he had completed his internship at Bellevue Hospital around 1890 and had hung out his shingle in Richmond. During his internship a charwoman engaged in sweeping out a railroad day coach was knocked down when a switch engine coupled onto it. She was brought to Bellevue and my father looked after her. She seemed to make a nice recovery and left the hospital after a day or two. But, believe it or not, she brought suit against the railroad to recover damages for permanent injuries, one of the allegations of her complaint being that she could not have any more children. Since she already had five, my father, not being versed in the law, felt that this might be shown in mitigation of damages, but not so! The case went to trial and my father was called from Richmond to testify. That being his first trip to the witness stand, the plaintiff's lawyer gave him a hard time, and the jury returned a verdict against the railroad company. My father went to the railroad's lawyer to collect his travelling expenses and fee, and the lawyer handed him a check in stony silence. Feeling somewhat apologetic, by father said, "Mr. Smith (I don't recall his real name), I just want you to know that I did the best I could," to which the lawyer replied "And God knows that was poor enough!" So this may be a case of "like father, like son."

The subject your chairman selected is The Relationship Between The Attorney and the Engineer on the Railroad. Because my railroad service has been largely confined to one company, my observations are based chiefly on the relations existing between the C&O's engineering and law departments, but I doubt whether they differ materially from those obtaining between the same departments of other railroads. I am glad to say that our departments have always been most cooperative, and I cannot recall an instance in which our engineering department was called on for information or assistance when it was not freely and willingly given. As one of our engineers expressed it, the relations between the departments are similar to those existing between players on a team. Each department has its particular job to do, but the success of their combined efforts depends on teamwork.

As you are aware, the legal questions submitted by a railroad's engineering department to its law department relate to a multitude of subjects ranging from routine side-track, utility-line, and road-crossing matters to main-line extensions and abandonments, highway occupancies and grade separations, and major construction projects, such as yards and additions, interlocking plants, joint facilities, bridges, piers, coal loading, ore-unloading and other port facilities and high-level dams on inland waterways, to mention a few.

The cooperation between the departments might be illustrated by outlining the manner in which an ordinary grade-separation project is handled with a state highway commission, which will be referred to as "state", and the federal authorities. When such a project is proposed the engineering department develops the pertinent data, including the nature of the company's title to the land or right-of-way at and near the proposed separation, that is, whether the company owns the land in fee or merely has an easement therein for railroad purposes, and what easements and rights, if any, are outstanding and will be effected by the project, the estimated cost of the work, whether federal or other aid is available, and to what extent if any the company might be deemed to benefit from the project and be expected to contribute to the cost thereof. Such data, including appropriate drawings, are then discussed with representatives of the law department in the light of the applicable statutes, regulations and other legal aspects, including the tax and accounting features involved when the company is required to contribute to the cost of the project, and efforts are made to anticipate problems that might arise and what position should be taken with respect thereto in ensuing negotiations with the state. And in most cases a preliminary draft of agreement between the company and the state is prepared and submitted to the law department for tentative approval. This draft contains, among other provisions, a brief general description of the project, specifies the work to be done by or on behalf of each party and the division of the cost thereof, if appropriate, together with a catch-all clause providing that any other work not specifically so assigned shall be performed by and at the expense of such party or parties as may thereafter be agreed upon. It also contains the customary clauses relating to the kinds and amounts of insurance to be taken out and maintained at the contractor's or project expense pending completion and acceptance of the work by the state. Frequently the draft will be accepted by the state without any or with only minor changes. But if major differences arise, the law department stands ready to assist in working out a solution.

Sometimes in the past, negotiations between our engineering department and the state were conducted to the final stages before the law department was consulted, but we have found that both time and trouble can be saved if the two departments work together from the early or preliminary stages.

I will not be presumptuous enough to attempt to discuss engineering problems with a group of railroad engineers, but will merely call attention to some instances in which legal questions arose in connection with agreements or cases handled either with our engineering department or which arose on other railroads, which I hope may be of interest.

In a recent case, one of our agreements obligated the state to require its contractor to bear the cost of furnishing railroad watchmen while the work was "in progress." The nature of the work and the dangers involved made it imperative that watchmen be kept on duty at all times, day and night, and no one questioned the necessity therefor. But the state's contractor refused to reimburse the company for the cost of providing watchmen during non-working hours on the ground that work on the project was not then "in progress." The state finally paid our bill, which amounted to approximately $8,000, but whether it collected from the contractor is not known. Most of our agreements of this character now provide that such service shall be furnished at the contractor's or project expense "until the project is completed and accepted by the state."

In another case, locally known as the "Pigeon Case," the C&O was not involved, but the cause of action arose on the property of another railroad under an agreement quite similar to one the C&O had made with a turnpike authority, whereby the author-

ity was granted an easement for the construction of its viaduct over a portion of the railroad's land leased for parking-lot purposes, in which the authority covenanted to hold harmless the railroad from damage resulting from anything "falling or being thrown from the viaduct." It developed that pigeons found the beams of the viaduct's superstructure particularly attractive for roosting, with the result that automobiles in the parking lot were decorated in a most unattractive way. The railroad called on the authority to indemnify it under the hold-harmless clause, and when the authority refused, instituted proceedings for an injunction and to recover damages sustained from reduction in rent. The authority defended on the grounds, among others, that the clause did not apply, that the authority did not own or have any control over the pigeons, and was not advised whether the damage occurred while the pigeons were in flight or perched on the viaduct. The court dismissed the suit, but I note that a bill was introduced at the last session of the state legislature to amend a section of the code which makes the killing of "homing pigeons" unlawful, so as to provide that pigeons congregating or roosting on structures devoted to business or industrial use will conclusively be deemed not to be homing pigeons and can be killed. Although the breed of the offending pigeons is unknown, their attraction to the railroad indicates that they may be "carrier pigeons," but if they don't behave better they may be "dead pigeons." Perhaps some revision of this type of agreement is in order.

On the more serious side, and if I may be excused from digressing from my subject, I will call your attention to a recent case involving two railroads which had entered into similar separate agreements with a director of highways (state), and a city, whereby the companies agreed to perform certain work in connection with a grade-elimination project. The agreements provided that the work to be done by the companies should be performed in accordance with certain plans and specifications and in the sequence therein designated. At the same time, the state entered into a separate agreement with a contractor covering other portions of the grade elimination, but there were no agreements between the railroad companies and the contractor. The nature of the work was such that none of the parties could perform its part in a single operation. Numerous ones were required, and the times of performance were spelled out in the plans and specifications. After the project was completed, the contractor sued the railroad companies to recover damages alleged to have resulted from their failure to carry out their contracts with the state in accordance with the time schedules, on the theory that the contractor was a third party or creditor beneficiary. In other words, that the obligations assumed by the companies in their agreements with the state were for the benefit of the contractor. The companies denied this, but the court held in favor of the contractor and the companies are faced with liabilities that could run into large amounts, if the contractor can prove its case. Consideration is being given to inserting in agreements of this character a clause to the effect that nothing therein contained shall be construed as being for the benefit of the state's contractor or any other third party, together with a requirement that the state insert a clause of like import in the agreement to be made by the state with its contractor relating to the same project.

A matter in which our engineering, law, and other departments collaborated, involved the shipment of a generator stator which, with blocking and the specially designed depressed car on which it was shipped, weighed approximately 965,000 lb, from the manufacturer's plant in Wisconsin to a power company's plant at Yorktown, Va. Because of its great size and weight the shipment was routed specially over the lines of 8 railroads, and I understand some 1760 miles of track, nearly double the most direct route between the points of origin and destination. Ordinarily the shipment would have been handled on a through bill of lading in common carriage over the transfer bridge

of a belt line in Norfolk onto a C&O carfloat for movement by the C&O across Hampton Roads to its float bridge at Newport News, and thence via its rails to destination. But because the belt line's transfer bridge had been damaged it was necessary for the manufacturer to arrange with the belt line, an independent contractor and with the C&O to have a belt line yard track extended and a temporary transfer bridge constructed so that the contractor could handle the shipment thereover onto a C&O carfloat for movement across Hampton Roads. Our engineering department was requested to approve the plans and specifications for the temporary transfer bridge and appurtenances, and agreements were drawn to cover this work, the furnishing of a carfloat and tug, the ballasting of the carfloat with loaded gondola cars, and the transfer and transportation of the shipment by the C&O in contract carriage across Hampton Roads. But because of such handling in contract carriage, it was necessary for our traffic people to notify the originating rail carrier that the C&O would not participate in a through bill of lading. I might add that our people were put on notice that the combined value of the stator and special car was $800,000, and that if the stator was not in service by the end of the year the power company would lose between 2 and 3 million dollars on account of its amortization schedule, so that, in addition to providing for special insurance on the stator and car, carfloat and other equipment, it was necessary to require insurance to protect the C&O against the liability it might incur on account of any consequential damage in the event the stator was destroyed or damaged so that it could not be put in service within the prescribed time. Due to careful planning and handling, the operations moved smoothly, and the stator reached its destination safely and without undue delay.

The two departments worked together constantly in connection with the construction by a West German firm of ore-unloading facilities at Newport News, Va., and the construction by another West German firm of ship-loading facilities at Presque Isle, near Toledo, Ohio, which facilities are believed to be among the most modern and up to date in the country. They are described in a paper titled "Dock Handling of Bulk Materials", prepared by R. C. Tench, our able materials-handling engineer, who presented at the annual joint AIME–ASME Solid Fuels Conference in 1958. As might be expected, the preparation of the agreements with foreign concerns presented a number of problems, but in order to avoid any questions involving conflicts of laws we inserted in each agreement a clause to the effect that the agreement would be deemed to have been executed in and would be construed in accordance with the laws of the state in which the facilities were to be erected, and that if arbitration proceedings became necessary they would be conducted, as therein provided, in such state. Among the other problems were those concerning the protection by insurance of shipments from the manufacturers' plants and overseas to the sites of the work, and relating to customs or duties required to be paid on the importation of components and materials.

Before concluding, I will refer to a high-level-dam project with respect to which the engineering and law departments worked together with the government's engineers and counsel in negotiating an option agreement, whereby the government was granted an option to purchase certain flowage easements along, under and across the C&O's right-of-way and tracks for the construction, operation and maintenance of the project in and along the Ohio River and its tributaries. The pool created by the dam will extend along the railroad for more than 55 miles. The negotiations resulted in a lump sum payment to the C&O to cover the purchase price of the easements and an agreed amount for protective work on its line of railroad and for the readjustment and reconstruction of its effected facilities. Time does not permit a discussion of all of the many problems which arose, but one important point was the separation and specification in the option agreement of the exact amount paid for the easements and the amount

allowed for protective and other work, so that the capital gain or loss arising from the sale of the easements could be definitely determined, and future income tax questions with respect thereto avoided.

During the negotiations the government recognized that where openings of existing arches and box culverts would be totally submerged by the pool created by the new dam, such openings would eventually be entirely closed by silt and that in such cases the railroad was entitled to replacement structures. The government further recognized that where existing structures would be only partially submerged by the new pool the present waterway openings would silt up to the new normal pool elevations and the Company was entitled to new supplemental drainage facilities to augment those portions of the existing waterway openings above the normal pool elevations that would be presumed not to silt up.

Since the inverts or flow lines of the new drainage facilities will be at or about the normal pool elevations of the new dam, that is, at elevations substantially higher than the flow lines or inverts of the existing drainage structures, it was recognized that run-off from storms on tributaries will cause headwaters upstream from the railroad to rise to elevations substantially higher than those reached under presently existing conditions by run-off from storms of the same magnitude. In order to protect the company from liability growing out of its being in a sense a party to the creation of conditions causing the waters to rise to the higher elevations, the government agreed to acquire in the name of itself and its assigns flowage or flooding easements in lands located on the tributary watersheds up to certain agreed elevations and to convey the same to the company without cost to it. George K. Davis, a former member of your organization, who retired from C&O's service only a few days ago, did outstanding work on this project and won the respect and admiration of the government's engineers and counsel.

Negotiations are expected to start before long between the government and the company with respect to two more high-level navigation dams which will affect the company's facilities and property, and I am informed that the pools to be created thereby will extend along our railroad for a total distance of approximately 127 miles. So it appears that the departments will be busy on these projects for some time to come.

In all of our projects to which reference has been made and many more that could be cited the members of the staffs of the engineering and law departments worked together in harmony and as a team, and that, in my opinion, and no doubt in yours, is the relationship that should exist "between the attorney and the engineer on the railroad." [Applause]

Chairman Hastings: Thank you, Mr. Oppenheimer, for a most interesting and informative address.

Mr. Vice President, this concludes the report of Committee 20.

Vice President Brown: You always learn something from these talks, gentlemen. I thought I had everything in the book in our agreements on grade separations, but you can be sure this matter of the pigeons will be taken care of in the fine print of the next one.

Thank you very much, Mr. Hastings, and members of your committee for the further valuable work of your committee during the past year on this most important matter of contract forms. And thank you, Mr. Oppenheimer, for your interesting and informative address emphasizing the close relationship which should exist between the engineering and legal departments of the railroads in the preparation of satisfactory contracts.

Mr. Hastings, your committee is now excused with the thanks of the Association.

Discussion on Engineering and Valuation Records

[For report see pp. 635–648]

[Vice President Brown presiding.]

VICE PRESIDENT BROWN: The next committee to make a report is our Committee 11—Engineering and Valuation Records, of which L. W. Howard, land and tax commissioner of the Chicago & Western Indiana and Belt Railway of Chicago is chairman. I shall be glad if Chairman Howard and the other members of his committee will come to the platform at this time and present their report.

CHAIRMAN L. W. HOWARD: Mr. Vice President, members of the Association and guests:

I should like to comment briefly on the work of this Committee, whose report appears in Bulletin 555, January 1960, pages 635 to 648, incl.

Assignment 1—Revision of Manual.

CHAIRMAN HOWARD: The committee has no report on this assignment but is proceeding with Manual revision on which it expects to report 50 percent completion next year.

Assignment 2—Bibliography on Subjects Pertaining to Records and Accounts.

CHAIRMAN HOWARD: I should like to call attention to the fact that the report on this assignment is a non-cross-indexed report issued annually, and any member of the Association desiring information concerning outside viewpoints on matters dealing with valuations for various purposes, depreciation or accounting should consult Assignment 2 reports of prior years in the AREA Proceedings.

Assignment 3—Office and Drafting Practices.

CHAIRMAN HOWARD: Under this assignment your committee is developing information to supplement the progress report submitted in Bulletin 555.

Assignment 4—Use of Statistics in Railway Engineering.

CHAIRMAN HOWARD: Under this assignment your committee is likewise developing information to supplement previous reports on the subject.

Assignment 5—Construction Reports and Property Records.

CHAIRMAN HOWARD: The committee is starting a study of systems for mechanizing the handling of shop and roadway machine index record cards.

Assignment 6—Valuation and Depreciation.

CHAIRMAN HOWARD: Your committee wishes to add that the regulations that were to be issued by the Treasury Department relative to the 30 percent reserve have now been released.

Assignment 7—Revisions and Interpretations of ICC Accounting Classifications.

CHAIRMAN HOWARD: Since our report was published the ICC has issued an order dated December 18, 1959, which discontinues the proceedings under Docket 32153 and affirms the existing betterment-replacement rules prescribed for track property in the Uniform System of Accounts for Railroad Companies.

Assignment 8—Simplification of Records to Determine Original Costs of Tracks to Be Used in Their Retirements from the Investment Account.

CHAIRMAN HOWARD: This assignment was divided into two parts. The report on the first part, which deals with average unit costs, is published on page 646 of Bulletin 555. The second part, which deals with record forms, was completed in 1959, but the material developed was considered to be Manual material, so it was submitted to Subcommittee 1 for inclusion with their report for next year.

Assignment 9—Simplification of Annual Reports on Form 588 to the Interstate Commerce Commission, and Underlying Completion Reports.

CHAIRMAN HOWARD: The committee appointed by the AREA and the Accounting Division, AAR, to work on this subject has prepared a preliminary report.

CHAIRMAN HOWARD: I should now like to have the subcommittee chairmen responsible for the assignments of this committee stand as I call their names. Assignment 1, W. A. Krauska, draftsman, Missouri Pacific; Assignment 2, J. B. Byars, assistant to chief engineer, Denver & Rio Grande Western; Assignment 3, D. G. Paeske, assistant engineer, Milwaukee Road; Assignment 4, M. C. Wolf, valuation engineer, Northern Pacific; Assignment 5, W. S. Gates, Jr., assistant to auditor–valuation, Chicago & Illinois Midland; Assignment 6, C. R. Dolan, assistant to valuation engineer, Missouri Pacific; Assignment 7, M. M. Gerber, accounting engineer, Baltimore & Ohio Chicago Terminal; Assignment 7, C. F. Olson, valuation engineer, Great Northern, and B. F. Nauert, valuation engineer, Terminal Railroad Association of St. Louis; Assignment 9, H. N. Halper, valuation engineer, Erie.

This completes the section of our report dealing with the work of the past year.

Among the many definitions of "depreciation" in Webster's is "decline in value of an asset due to such causes as wear and tear, obsolescence, etc." This one is of particular interest to business leaders in all fields because it is of importance in the financial aspects of business operations due to its impact on operating expenses, working capital, and taxes—both income and ad valorem. As engineering officers of railroad companies, it is necessary that we understand its many ramifications, and the opportunity to present this subject before the Association should provide food for thought for all of us.

We are fortunate in having with us today three outstanding railroad engineers who will speak on some of the most important aspects of the subject, "Depreciation and Its Impact on Budgets and Maintenance Expense."

I hope that the papers presented will raise questions important to you, because we know that the speakers cannot entirely cover this large subject in the limited time afforded them. At your seats you will find cards on which you may write such questions. Identify yourself on the card by name and address so that the answer can be sent you and be published if there is not time to answer it from the rostrum.

Our first speaker is a civil engineer from Ohio State University who entered railroad service in July 1916, as a transitman with the Pennsylvania Railroad at Detroit, Mich. In 1918, he joined the Michigan Central Railroad as a draftsman in its valuation department and served that company in Detroit as junior engineer and assistant engineer until 1950, when he moved to New York as valuation engineer. He was promoted to chief valuation engineer, New York Central System, in 1951, and retired from railroad service on December 31, 1959. He is the immediate past chairman of this Committee (years

1956, 1957, and 1958) and at the time of his retirement, was general chairman, General Committee, Valuation Division and Chairman of the Engineering Committee, AAR. His qualifications being obvious, I now present Morton Friedman, retired chief valuation engineer, New York Central System, who will propound the viewpoint of the valuation engineer.

Depreciation and Its Impact on Budgets and Maintenance Expenses—from the Viewpoint of the Valuation Engineer

By Morton Friedman

Retired Chief Valuation Engineer, New York Central System

The inclusion of a charge in current expenses for depreciation of physical property has been considered by industry as one of the costs of doing business for a long period of time. This expense relating to roadway property had not been recognized as proper accounting by the railroads originally and was vigorously protested when it was proposed to make it mandatory. The railroads' position on depreciation was that a railroad is a continuing property and is maintained by what is known as the replacement method, under which, as the service life of any part or piece of a physical property expires, it is replaced by a new part and the cost is charged to operating expenses. In the original inventories that were required to be made by the Interstate Commerce Commission under the Interstate Commerce Act, the cost of reproduction new and the cost of reproduction less depreciation were required to be found as of a date of inventory and were later embodied in their Engineering Reports. The railroads resisted the findings by the Commission as to cost of reproduction less depreciation, their stand being that the depreciation which was deducted in the Engineering Reports was merely an estimate of a future operating cost and not depreciation in any sense.

A number of efforts were made by the Interstate Commerce Commission to prescribe depreciation accounting for roadway property, but they were successively postponed until January 1, 1943, when the Commission required such accounting to be set up for roadway property, exclusive of the track accounts.

As a beginning, I will attempt to explain the principles of depreciation accounting briefly for the reason that a number of you may not be entirely familiar with the procedures that are prescribed and the terms that are generally used.

The term depreciation itself has many different aspects:

(a) *Physical Depreciation,* which may be described as an actual loss or decrease in value which can be measured by the ratio of the current condition of the property to its condition when new. This aspect is generally used in cases of sales of property or determination of insurance claims due to casualties. This kind of depreciation is usually caused by deterioration, wear and tear from use, accident or castastrophe.

(b) *Functional Depreciation*—This usually stems from inadequacy, insufficient capacity and obsolescence. When a piece of property depreciates functionally, it is usually due to the invention of new property or improvements that affect efficiency and economy of operation. Property that becomes functionally obsolete should be replaced with more modern property, resulting in improvement and economy of operation.

(c) *Accounting Depreciation*—This term is used to express the amount of the charge to annual operating expenses that represents the cost of using physical property in our operations that eventually becomes subject to physical or functional depreciation. The Interstate Commerce Commission definition is, "The loss in service value not restored by current maintenance or covered by insurance." The present discussion will be confined to this aspect of depreciation.

The definitions of the ordinary terms of the depreciation vocabulary are as follows:

Depreciation Base—This consists of the actual original cost if known, or if unknown, the estimated original cost of the depreciable property used in transportation service.

Service Life—This is the average life of depreciable property during which it is used in operation. It is based on previous experience, usually from the age of property at the time of its retirement.

Service Value—This is the cost of the property as included in the depreciation base less the estimated salvage which may be recovered upon retirement.

Depreciation Rate—This is the percentage that is applied to the depreciation base of the property to produce the annual charges to operating expenses for depreciation.

Annual Depreciation—This is the amount charged to operating expenses annually which represents the consumption of the useful service value of physical property used in the operation of the railroad. It is the product of the depreciation base and the depreciation rate.

Depreciation Reserve—This is the balance sheet account representing the amounts of the annual depreciation charges that have been made to operating expenses from the date depreciation accounting was begun to the current date for property still in service. It is a credit account and is generally interpreted as the amount which must be deducted from the original cost of the property to reflect its depreciated book value. The service value, as defined above, of depreciable property is charged to this reserve at the time of its retirement.

Physical depreciation and functional depreciation are usually the causes for the retirement of depreciable property. Through depreciation charges to operating expenses, an amount will be recovered that will provide funds to expand plant, to make replacements and to increase working assets in a growing enterprise. Its inclusion in operating expenses reduces net income by the amount representing the consumption of plant in our operations. Depreciation is as much a cost of doing business as labor and material, and the failure to include it in an operating statement does not produce the true operating cost.

The present Uniform System of Accounts for Railroads excludes from depreciable property all of the track elements and certain other roadway property. The basis for this exclusion is that its condition is currently restored by maintaining it to the highest standards required for safe operation. The maintenance charges for replacement of non-depreciable property are made to operating expenses. The service value of such property is also charged to operating expenses at the time of its retirement.

Many of you may wonder what the function of the valuation engineer may be in the procedures described above, which appear to be primarily an accounting matter. The depreciation base has been prescribed by the Interstate Commerce Commission as the original cost or the estimated original cost of the property as found by its Bureau of Accounts as of the latest date, adjusted by additions, betterments and retirements

for subsequent years as reported by the carrier. On many railroads the valuation engineer maintains all of the property records, and it is his job to prepare the depreciation base by the primary accounts and to keep it up to date from his records. It is also his job to compute the depreciation rates and to police the property record carefully to determine that the rates currently reflect the changes made in the property that many tend to lengthen or shorten the estimated service lives thereof. He negotiates the necessary changes in rates with the ICC Bureau.

Since 1943 most of our railroads have elected to adopt depreciation accounting on roadway property for income tax purposes. Some minor modifications in the depreciation base, depreciation rates and other variations from the ICC practices are required by the income tax regulations, but the overall principles are similar. The charges made to operating expenses for depreciation represent actual dollar savings in income taxes for the reason that they are deductions permitted in the computation of taxable income.

The operating budgets of the engineering and maintenance departments include forecasts of the annual depreciation charges, which are furnished by the valuation engineer. He also furnishes the estimated additional depreciation charges for proposed large new installations and improvements that should be included in the forecasts for those departments.

The panel members who follow me will endeavor to explain the application of the charges to depreciation in the railroad's accounts as they affect their functions, and this introductory and explanatory review should help you to understand their significance. [Applause]

Chairman Howard: Thank you very much, Mr. Friedman. We all enjoyed your talk. A good many of us possibly never heard of some of the terms you defined.

Our second speaker was born in Carbondale, Ill., where he attended school, including the University of Southern Illinois, where he was captain of the track team. He he has been "on the run" ever since. In 1932, he moved to Colorado, where he first taught in high school and later, in 1936, entered the service of the Denver & Rio Grande Western as a chainman on the narrow-gage lines. He held various positions, ever upward, until in 1949 he was made assistant engineer of capital expenditures. In 1951, he became engineer of capital expenditures and in 1957, assistant to chief engineer. In his present position, he is in on all phases of engineering and maintenance of way work as well as being directly responsible for the preparation and control of the budget and valuation work. It is my pleasure to introduce J. Bert Byars, assistant to chief engineer, D&RGW, who will discuss our subject from the viewpoint of the engineer maintenance of way. Mr. Byars.

Depreciation and Its Impact on Budgets and Maintenance Expenses—from the Viewpoint of the Engineer Maintenance of Way

By J. Bert Byars

Assistant to Chief Engineer, Denver & Rio Grande Western Railroad

Maintenance officers on all levels should be concerned with budget procedures and what constitutes a budget now more than at any time in the past. Their concern should apply not only to the maintenance budget, but also to the improvement or capital expenditure budget, because improvement budgets frequently require charges for operating expenses which eventually wind up in charges to the maintenance budget.

A maintenance budget is an estimate or forecast of the cost of operation and is used to guide the maintenance program over a period of time—usually a year. It is the tool by which management fixes responsibility in the maintenance officer for producing the maintenance department's contribution to overall company operations.

It is important that all maintenance officers be thoroughly familiar with the uniform classification of accounts and the regulations of the ICC relating to assignment of charges to the proper accounts. This knowledge is essential to the proper distribution of cost to the accounts for additions, replacements, betterments, renewals, and retirements.

However, a maintenance budget is never considered as fixed or inflexible. It is made and administered in a manner which permits revisions to cope with fluctuations in income, extraordinary expense, and such other corrections found necessary by actual experience. Therefore, while the budget may be prepared for a year, it is generally handled by monthly allowances, which allotments secure a more effective control for the welfare of the business.

The amounts to be expended for maintenance and betterments of the property are established by management allotments of funds based on management's estimate of revenue, working capital available, and what is best for the business, and it is through the medium of the budget that a program for expenditure is developed to best suit the conditions of the property to be maintained or renewed. When revenues are not produced as anticipated, management, mindful of its duty to the public for service and to the owners for a return on their investment, is confronted with the problem of ordering budget changes to meet the necessities of the case. Extraordinary conditions, such as washouts, wrecks, snow storms, and the like, produce extraordinary expense, and the maintenance engineer finds himself charged with the task of reducing expenses in less critical areas or on unaffected divisions so that his contribution to annual profit results will be maintained as budgeted.

To enforce his budget the maintenance officer must be continually alert to changing conditions, constantly review the established standards and comparison of performances. These devices may indicate to him the need for new and more efficient methods which will substantially reduce unit costs in the future. Such changes may, in turn, warrant immediate capital expenditures to bring about increased economy. Maintenance of way research assists the maintenance officer in findings of this type, which must first be referred to the management for consideration, after which adoption of new and more aggressive policies may be effected. These may materially affect the budget and require allowed overcharges or transfer of budget funds.

I have previously discussed our position with respect to those items and aspects of the budget which are relatively flexible. I should now like to move into the area of budget expenses where expenses are incurred over which maintenance people have little control and which are inflexible budget items. One of these is the charges for depreciation of road property. Depreciation charges are a necessary, continuing operating expense item. They will remain so long as wear and tear, which occurs in spite of the best efforts to repair, continues to erode and deplete the plant. Thus depreciation charges for the depreciable road property are in the nature of a fixed charge against current operations and a major item of budget.

Prior to the inception of mandatory depreciation accounting, items now depreciable were under retirement accounting, that is, the service loss (cost less salvage) was charged to operating expenses when the property was retired. This method brought about widely fluctuating charges to operating expenses because of fluctuations, dollarwise, in retirements. The purpose of depreciation accounting is to spread the service loss annually

throughout the estimated service life so that operations for each year are charged with a proportionate share of the estimated loss in value.

Those roadway accounts which are non-depreciable are so classified because all losses in useful value are assumed to be completely restored by maintenance, and it is important that maintenance officers understand that retirements of such property involve charges against expense at the time of replacement. This feature should be carefully considered when budget forecasts are prepared so that all anticipated retirement losses of non-depreciable property are included. Control of this item requires careful planning, an intimate knowledge of local conditions, and proper execution of a planned timetable.

The labor cost for the demolition of retired property, both depreciable and non-depreciable, is an operating expense charge additional to the depreciation charge on depreciable property and the service loss charge on non-depreciable property, and must be included in the budget forecasts so that sufficient funds will be available for the necessary maintenance requirements.

Program maintenance work can be forecast accurately and provide funds for roadway repairs, right-of-way maintenance, tools, supplies, maintenance of roadway equipment, incidental operating expenses arising out of property changes that are found necessary as additions to the authorized program work, etc. Such expenses are additional and must be provided for in advance so they will not adversely affect the maintenance officer's operating program.

Items of expense which arise from insurance, personal injuries, and joint facility charges representing the carrier's portion of the cost incurred by others resemble depreciation charges because they are of the nature of fixed charges which can be predicted with reasonable accuracy on the basis of past records.

It is possible to reduce charges for depreciation by careful policing of the property to insure prompt retirements of depreciable items no longer used or needed in operations. This has the immediate effect of increasing operating expense for demolition in the year of retirement, but is of value in the years to come. If the depreciable item to be retired is insured, it reduces the expense of insurance, and maintenance officers should be certain there is good communication between their departments and the insurance agency of the carrier to see that requirements are promptly reported and short-term premium rebates obtained.

Maintenance officers should also carefully search for any depreciable property which can be retired in place, such as unused water and sewer lines, unneeded retaining walls, track slabs, etc. Retirement of unneeded facilities may be due to obsolescence because of change in the needs of operation and thus produce tax credits for obsolescence which are important to management capital requirements.

The proper control of salvaged material and its reuse or sale also plays an important part in the effective control of the maintenance officers' budget. The control of the maintenance budget cannot be effected by the maintenance officers alone. Division engineers, roadmasters and all other supervisors should have a thorough knowledge of the maintenance program and its control system. The more people responsible for proper handling of the work, the better the control which can be effected.

It has been the practice of many railroads in the past to keep matters dealing with finances highly confidential, but it is now being recognized that it is important that maintenance officers know more about the operating budget and its functions in order to better control the results of operations. [Applause]

Chairman Howard: Thank you, Bert.

Our third and last speaker on this topic entered Frisco service in 1915 and has had experience ranging from extra-gang timekeeper to operating department positions to assistant to chief engineer, which he has been since 1953. It is my pleasure to introduce E. W. Smith, assistant to chief engineer, St. Louis–San Francisco Railway, Springfield, Mo., who will present the viewpoint of the chief engineer.

Depreciation and Its Impact on Budgets and Maintenance Expenses—from the Viewpoint of the Chief Engineer

By E. W. Smith

Assistant to Chief Engineer, St. Louis-San Francisco Railway

The chief engineer, as custodian of fixed property, is interested in both construction and maintenance and their relation to revenue. He must see that the property is maintained to the best advantage with the money available, and at the same time provide for new plant and equipment.

Depreciable property is essentially structural, and includes buildings, bridges, fences, water and fuel facilities, wharves and docks, communication and signal systems, and roadway machines; also, various kinds of underground facilities such as drainage and sewer systems, servicing facilities for water, air and steam.

With increased cost of both labor and material, the chief engineer's prime interest in depreciation is:

1. Effect on expenditures—both fixed and variable.
2. Practical and realistic depreciation rates for both ICC and Internal Revenue Service purposes.

Effect on Expenditures

On some railroads, depreciation is a fixed or overhead charge, together with expenditures such as for joint facilities, insurance, personal injuries, additions and betterments adjustments, and retirements of non-depreciable property, together with such budgeted or equalization programs as new and relay rail, cross ties, etc. Some of these expenditures can be controlled, while others cannot, by the chief engineer.

Equalizing or distributing fixed charges over the 12-month period permits better stabilization of monthly maintenance allowance or budget for variable charges—considering revenues—and permits retirement (other than actual labor dismantling) of property included in the depreciation base, at any time, even in lean revenue months.

The chief engineer has moderate control over depreciation charges that he may exercise by policing the property to make sure that any depreciable property not used in operation is promptly retired or disposed of through sale or lease. If such property is not demolished or sold, but upon retirement as operating (transportation) property, becomes available for lease to outside party (individual or company), it should be promptly transferred to non-operating classification. This can be done either by AFE or by checking with the department handling depreciation to make sure that all depreciable property not used in operation is promptly deducted from the ICC accounting depreciation base—thus reducing the depreciation charges that are a part of the budget or maintenance allowance.

As an example—a discontinued storeroom building now in Account 731—Road and Equipment Property, may be transferred to Account 737—Miscellaneous Physical Property, so that any expense for repairs and maintenance to such structure will be charged

to Account 511—Income from Non-Operating Property, instead of paying for such work out of the maintenance allowance.

Such transfer cannot be made unless the structure in its entirety is devoted to non-operating service. However, structures with divided use may be considered as structurally separate where an entire longitudinal section, or any substantial portion for its entire width and length, is leased exclusively to an outside individual or concern, or otherwise devoted to revenue producing non-operating service. In that event, maintenance on such portion may be charged to Account 510—Miscellaneous Rent Income, and not be charged to the maintenance allowance. An example would be a substantial portion of freight house leased to a carloading company.

An exception would be any jointly owned terminal property, such as a freight house, as ICC Accounting Classification specifies that maintenance expense incurred on such facilities be charged to Account 278—Maintaining Joint Tracks, Yards and Other Facilities.

Case A–200, Interpretations of ICC Accounting Classification, issued January 15, 1959, provides, where retirements cannot be identified with or do not result from the usual business operations of the year, that the service value may be excluded from current operating expenses and charged to surplus or retained income. In such instances the service value (ledger value less salvage) of non-depreciable property may be charged to Account 616—Other Debits to Retained Income, and does not affect current revenue, thereby preventing an appreciable impact on maintenance allowance. This includes retirement of a branch line, segment of track such as second main, or other facility, constituting a permanent reduction in plant—unless a special reserve has been set up to take care of the loss. This provision is very important, and, if possible, the chief engineer should make sure that the AFE's covering such retirements reflect the proper accounting for the service losses.

All new construction or facilities classified as depreciable property, unless offset by retirements, increase the charges for depreciation. Since depreciation accounting was made mandatory, there has been a substantial increase in the amount credited to "Depreciation Reserve" on a number of railroads. An example would be a new electronic hump yard.

Practical and Realistic Depreciation

Working capital can be seriously impaired if current operations are not charged with all expenses. Depreciation and retirement losses represent a reduction of investment in fixed assets and are properly chargeable to operation. In depreciation accounting, it is important that the years of service be determined with reasonable accuracy; otherwise charges against each year's operations may be incorrect.

Usage applying to a building influences its life expectancy. A change in service life will change the rate of depreciation from the standpoint of both ICC accounting and income tax—and to that extent the chief engineer is interested in practical and realistic depreciation rates.

As an example: An estimated life of 50 years was established for a warehouse. The Internal Revenue agent pointed out that on the basis of prior studies the chief engineer estimated the life of brick and masonry structures to be 70 years and suggested that the railroad should use 70 years in computing the depreciation allowable on this particular structure. The building had an exposed steel frame, concrete block sidewalls, concrete floor, poured gypsum roof deck, and built-up asphalt roofing. The chief engineer was called upon and explained the basic design was such that the structure would reach obsolescence in 50 years.

In the past few years there has been a significant change in the service life of maintenance of way work equipment chargeable to ICC Account No. 37—Roadway Machines, which is one of the depreciable accounts. For example, I have in mind the case where 75 percent of the investment in this account represented track motor cars when the original service life was established as 15 years for ICC and 20 years for Internal Revenue Service. With the advent of present day mechanized work equipment, and the advances, changes and improvements being made each year, this service life is no longer practical or realistic.

Some of the new mechanized work equipment undergoes changes or is improved so fast that it is obsolete within three years, and a railroad cannot afford to purchase such units unless they can at least more than pay for themselves within that period.

Contractors use a large number of items of work equipment that are also used by railroads. Contractors consider the service life of equipment such as tractors, cranes, etc., from 4 to 6 years, depending upon condition. The average is 5 years, or 10,000 hr based on 2,000 hr per year. Actually the service life for depreciation of this type of maintenance of way work equipment should be based on hours of operation. This method, however, is not permitted by ICC regulations, but it may be possible to prevail upon the Internal Revenue Service to adopt it.

The leasing of maintenance of way work equipment at present affords some relief in connection with the depreciation feature, but since the rental charge must come out of current revenues, this reduces the money available for construction and maintenance and the lessor includes depreciation in his rental.

Income tax payments on most railroads amount to as much as 52 percent of the net earnings. The depreciation charge to operating expenses has a direct effect on net income, and unrealistically long service lives presently prescribed for railroad property, which produces low rates, decreases the annual depreciation charge and thus increases the income tax liability. The Internal Revenue Service is checking depreciation rates closely, and it is the responsibility of the chief engineer to furnish information as to the useful life of fixed property as well as roadway machines and work equipment included in depreciable accounts, so that realistic service lifes can be established.

Summation

Removal of non-essential property from the investment account eliminates future maintenance, reduces future depreciation charges, and in some cases affords relief from ad valorem taxes; while a practical and realistic depreciation base or rate insures proper depreciation charges—all of which contribute to available working capital from which we procure the funds required for the replacements and expansion in plant and equipment necessary to continued successful operation.

It is, therefore, very desirable that the chief engineer and his staff understand and appreciate the importance and effect of depreciation, particularly as it relates to construction and maintenance budgets, as well as income tax and net earnings. [Applause]

Chairman Howard: Thank you, Mr. Smith.

I told you when we opened this program, that there would be cards at the seats on which you could write any questions. However, I find that due to the shortness of time or the over run of time that has taken place this afternoon, we should cut off this presentation of our committee at this time. However, I would appreciate it, if any of you have questions, if you will submit them to the ushers in the aisles who will

turn them over to me. We will send you the answers in the mail and then send them also to Mr. Howard for inclusion in the Proceedings as though they had been answered from the floor.

Mr. Chairman, that ends our presentation.

[In response to the invitation of Chairman Howard, three Association members submitted written questions, which, with their answers, are printed below.]

A. B. Hillman, Jr., (C&WI): Does the balance in the depreciation reserve account represent money available for replacement of plant and equipment?

Morton Friedman: No. The depreciation reserve account is simply a balance sheet book account to which all depreciation charges to operating expenses are credited and to which the cost of property retired, as included in the depreciation base, is charged at the time of retirement. In effect it represents the amounts charged in the past as the cost of the depreciable property consumed in producing service. Funds for necessary replacements and for the acquisition of new property can be obtained only from current earnings, appropriations of earned surplus, temporary borrowing or long-term financing.

E. P. Hackert (D&RGW): How would you suggest that on-line supervisors be trained to program their required work to better control maintenance of way allowance and budget?

J. Bert Byars: In answering this question I would say that some of the railroads over the country have recognized the value of knowledge of budget procedures for all supervisory personnel, and have held seminars or group discussion meetings calling in all supervisors from various departments so that they might gain knowledge concerning finances, accounting and budget procedures on their respective roads. These discussion groups are generally led by officers of the company who handle the allowance in their respective departments, as well as representatives of the traffic, accounting and budget departments. I feel that this is probably the best method for supervisors in the field to gain knowledge in the above subject.

W. D. Chapel (C&WI): Is the amount chargeable to depreciation each year sufficient to cover the amount of service lost? If it is—would that amount be sufficient for repair budget?

E. W. Smith: Under present day conditions the amount chargeable to depreciation each year is not sufficient to cover service losses. The ICC and IRS insist on long service lives which makes very low rates of depreciation. This, coupled with inflationary or increased cost of material and labor, makes the amount chargeable to depreciation inadequate to cover repair budget.

[President Woolford resumed the chair.]

President Woolford: Thank you, Mr. Howard, for the interesting and informative presentation of your committee. More than is realized by some, your committee deals with a most important aspect of railroading, and we appreciate your keeping us continually informed concerning it. May I thank especially those who participated in your symposium, which was most interesting and enlightening. Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Yards and Terminals

[For report see pp. 259–268.]

[President Woolford presiding.]

President Woolford: Next, we will hear the report of Committee 14—Yards and Terminals, of which A. S. Krefting, assistant chief engineer, bridges and structures, of

the Minneapolis, St. Paul & Sault Ste. Marie Railroad is chairman. Mr. Krefting, I will appreciate it if your committee will please come to the platform and present its report.

Mr. Krefting, I do not know just how your presentation will be made, but if separate report presentations are to be made by your subcommittee chairmen, I shall appreciate their taking places here at the main speaker's table with me, as close to the podium as possible, in the interest of saving time. Mr. Krefting, I am pleased to turn the meeting over to you.

Chairman A. S. Krefting: Mr. President, members of the Association and guests:

During the past year, Committee 14 lost through death two former, faithful members, Professor W. C. Sadler and Col. Huriesco Austill. Professor Sadler was a member of this committee from 1930 until his death, October 14, 1959. He was also a member of Committee 24, and an appropriate memoir has been prepared by that committee.

Col. Austill, retired chief engineer of the Terminal Railroad Association of St. Louis, was a member of this committee from 1941 to 1949. He was also a member of Committee 7 for some 36 years, and a memoir will later be presented by that committee.

During the past year, Committee 14 conferred the honorary degree of Member Emeritus on Charles H. Mottier. Mr. Mottier, retired vice president of the Illinois Central Railroad, has been an outstanding member of this committee since 1922 and served as president of this Association in 1948–1949.

Committee 14 has seven committee reports and a special feature film. The committee reports appear in Bulletin 553, pages 259 to 268. Discussion from the floor is invited at the end of each report. The subcommittee chairmen have worked hard on their assignments, and I am glad that they are here to present their reports at this time.

Assignment 2—Classification Yards.

Chairman Krefting: The report on Assignment 2 will be presented by Subcommittee Chairman R. O. Balsters, assistant engineer, Santa Fe.

R. O. Balsters: Under this assignment, your committee presents a report on Present Trends in the Design of Yards, which can be found on page 261 of Bulletin 553. The trends are stated without detailed discussion thereon.

The trend toward complete automation is evident in many of the hump yards now in operation and under construction. Automation requires test sections at strategic locations between the crest and the group retarder for the measurement of rolling resistance.

Yards are being built or contemplated with a trend toward flatter or level grades in the body tracks. Some of the electrical and mechanical appurtenances used in up-to-date yards are mentioned in this report.

Modern communications, such as television, voice recorders and talk-back speakers, are conducive to a well coordinated operation.

This report is presented as information.

President Woolford: Your report will be so accepted, Mr. Balsters.

Assignment 3—Scales Used in Railway Service, Collaborating with Electrical Section, AAR.

Chairman Krefting: Subcommittee 3 has during the past few years made a study of two-draft weighing of freight cars. While the committee is not yet ready to submit a formal report, Subcommittee Chairman Hubert Phypers, supervisor scales and weighing, Canadian National Railways, will at this time give a brief progress report.

Hubert Phypers: Work is progressing on Part 5 of Chapter 14 of the Manual, looking to bringing the specifications up to date in time for reprinting in 1962. Study is being made of two-draft weighing of freight cars, both gravity-motion, uncoupled, and coupled-in-action. Data are being assembled to support and illustrate the accuracy to be expected from these weighing procedures, which will be presented as information in our next report.

On August 11th, 1959, at the invitation of International Railroads' Weighing Corporation, representatives from the AAR Research Center, three members of this committee, and a member of the Western Weighing and Inspection Bureau, observed a test run of this company's two-draft coupled-in-motion weighing installation at Hammond, Ind.

President Woolford: Thank you, Mr. Phypers. Your report will be accepted as information.

Assignment 4—Gradients for Flat Switching Yards.

Chairman Krefting: The report on Assignment 4 will be presented by Subcommittee Chairman B. E. Crumpler, assistant chief engineer, Norfolk & Western.

B. E. Crumpler: The committee's final report on this subject includes a tabulation of data obtained by questionnaire from 10 railroads covering 19 locations where assisting gradients produce a greater total of cars handled per shift than would be possible without the aid of assisting gradients.

The report indicates that a specific formula is not practicable for general application of assisting gradients because local conditions of climate, alinement, track maintenance, and rollability of cars govern the magnitude and length of such grades. Satisfactory operation can generally be obtained by providing a 0.3 percent descending grade to the leaving ends of ladders and a 0.1 percent descending grade beyond the leaving ends of ladders, compensating for curvature between the ladders and the straight portion of body tracks.

The report is presented as information, with the recommendation that the subject be discontinued.

President Woolford: Thank you, Mr. Crumpler. Your report will be so accepted.

Assignment 5—Influence of Roller-Bearing Cars on Design of Hump and Flat Yards.

Chairman Krefting: The report on Assignment 5 will be presented by D. C. Hastings, superintendent Potomac Yard, Richmond, Fredericksburg & Potomac, in behalf of the subcommittee chairman, W. H. Goold, materials engineer, New York Central.

D. C. Hastings: Tests have been made to determine the rolling resistance of roller-bearing cars, and the results have indicated no appreciable difference between them and cars with solid or friction bearings, except for lower starting friction and greater uniformity in rolling resistance. If grades have been designed for the easy-running friction-bearing cars, then the roller-bearing cars can be handled without difficulty.

President Woolford: Thank you Mr. Hastings. Your report will be accepted as information.

Assignment 6—Facilities for Loading and Unloading Rail–Truck Freight Equipment.

Chairman Krefting: The report on Assignment 5 will be presented by Subcommittee Chairman H. J. McNally, area engineer, Pennsylvania Railroad.

H. J. McNally: Your committee recommends that the data on Rail–Truck Loading and Unloading Facilities printed on pages 263–264 of Bulletin 533 be adopted and published in the Manual as Sec. J under "Freight Terminals", Part 3, Chapter 14. I so move.

[The motion was regularly seconded, was put to a vote, and carried.]

Assignment 7—Waterfront Terminals.

Chairman Krefting: The report on Assignment 7 will be presented by Subcommittee Chairman W. H. Pollard, division engineer, Chesapeake & Ohio.

W. H. Pollard: Mr. President, Mr. Chairman, members and guests:

Your committee presents as information under Assignment 7—Water Front Terminals, a report on Coal Piers, which is published in Bulletin 533, page 264, November 1959; therefore, I will not consume your time with the reading of this report.

The report describes briefly the primary components and operation of three principal types of coal-handling facilities, namely, the high-level pier, the low-level pier and the belt-conveyor pier, now employed for use in transferring coal from railroad cars to vessels. Included under the belt-conveyor-type pier is a brief description of what is believed to be the largest single-vessel coal-loading pier in the world. It has an 8-ft-wide conveyor belt, and the capacity of its single movable tower is 6000 tons per hr.

The report is presented with the recommendation that it be included in the Proceedings as information.

President Woolford: Thank you Mr. Pollard. Your report will be so accepted.

Assignment 8—Present Trends in Yard Maintenance.

Chairman Krefting: The report on Assignment 8 will be presented by Subcommittee Chairman C. J. Morris, chief engineer, Grand Trunk Western.

C. J. Morris: Traditionally railroads have maintained tracks on main line to a higher standard than in yards. The application of improved materials and the mechanization of work methods on main-line territory has resulted in better and more economic maintenance. The satisfactory progress attained in this field has recently permitted more attention to be directed to yard requirements, resulting in a trend to maintain yards to an increasingly high standard, which will:

(a) Expedite handling of cars in and out of yards.
(b) Permit faster classification of cars.
(c) Reduce damage to lading during classification operations.
(d) Maintain performance of speed-control devices.
(e) Minimize interference to yard operations.
(f) Reduce long-range maintenance costs.
(g) Improve safety and working conditions for yard personnel.

To attain these benefits the standard of maintenance of yards is being improved in the following ways:

(a) Use of better track materials.
(b) Increased mechanization of maintenance operations.
(c) More programming of maintenance work.
(d) Better deployment of yard maintenance forces.
(e) Fuller cooperation from operating personnel.

It is intended to examine carefully each of these aspects of the trend and to set down the findings in a further report.

President Woolford: Thank you Mr. Morris. Your report will be accepted as information.

Chairman Krefting: The committee would like at this time to present a film showing the construction and operation of the Pittsburgh & Lake Erie retarder yard near Youngstown, Ohio. E. G. Brisbin, chief engineer of the P&LE and a member of this committee, will give you a few highlights about the yard before the showing of the film.

E. G. Brisbin: Mr. President, Mr. Chairman, gentlemen:

Before the showing of the film of the new Gateway Yard at Youngstown, Ohio, owned and operated by the Pittsburgh & Lake Erie Railroad, I would like to acquaint you with some of the vital statistics concerning the yard.

It is located 60 miles west of Pittsburgh, Pa., and just east of Youngstown, Ohio, near the western end of the P&LE. Its construction was authorized on July 26, 1956. The first construction work was undertaken in September 1956, and the track work started in April 1957. The first cars were classified in October 1957, and the hump was in complete operation on November 11, 1957. This yard is long and narrow due to the fact that it is built between the main line of the Baltimore & Ohio on one side, and the Youngstown Sheet & Tube Company plant and the Mahoning River on the other.

Size

Area, 210 Acres; 5.2 miles long, 80 to 610 ft wide. Height of crest of hump: 28 ft above natural ground level.

Trackage and Capacity

73 miles of track with total capacity of 5848 cars.
35 classification tracks with capacity of 1697 cars.
21 receiving and departure tracks—3076 cars.
3 repair tracks—93 cars, spot system. Shed 100 by 150 ft clear span.
10 local tracks—226 cars.
238,150 ties were used.
249 turnouts constructed—380 turnouts removed.
2.3 miles of driveways and roads.
Parking area capacity—270 automobiles.
Electronic track scale—200-ton capacity motion weighing, 105 ft long.

Communications

25 miles of communication cable.
1 television camera and receiver.
15,000 ft of 4-in pneumatic tube.
500 ft of 3-in pneumatic tube.
All yard engines equipped with two-way radio.
9 radio frequencies (car inspector 2; hump 1; yards 1; dick track 4; recorder 1).
21 walkie-talkie two-way radios (car inspectors, yard, hump).
1 auto terminal trainmaster.
3 remote-controlled sound recorders.
45 paging speakers.
140 talk-back speakers.
7 cordless intercommunicating consoles.
1 dial switchboard including inter-city dialing.

Signaling, Interlocking and Retarder System

280 miles of wire and cable.

1 master retarder—220 ft in length, electro-pneumatic, 70 cylinders.

5 group retarders—each 90 ft long, electro-pneumatic, 28 cylinders.

34 direct-acting electro-pneumatic switch machines for the classification yard.

50 dual-control electro-pneumatic switch machines, 47 for the receiving yard and three for the hump lead.

Special equipment, including radar and electronic computer for speed control, rolling-resistance measurement and determining the proper leaving speed from the group retarders.

Automatic switching push-button machine operated by conductor to control switching classification yard.

Track-fullness system, including indicator which automatically records cars entering each classification track and transmits into computer information on how far each cut must travel on its designated track. The distance is automatically adjusted for each car that enters each track after resetting by retarder operator.

Inductive cab signal system for providing engineman of the humping locomotive a visible and audible indication.

Two yard-track indicators for designating to incoming trains the track in the receiving yard they are going to enter.

Lighting

19 floodlight towers—216 floodlight units, 1500 w each, rated at 40,000,000 beam candlepower.

Hump area 22 mercury street lighting units at 400 w each.

Construction

165,000 cu yd of earth and select material moved.

260,000 tons of ballast added.

20 buildings, including towers, offices and utility buildings.

5,500 cu yd of concrete.

208 manholes and catch basins.

19,030 lin ft of surface drainage pipe.

810 wood piling—hump crest building, 35 ft, hump bridge, average 30 ft.

Hump Grades

3.16 percent approaching hump.

3.00 percent leaving hump.

5.903 percent through master retarder.

0.733 percent between master and group retarders.

1.58 percent through group retarders.

0.12 percent in body tracks.

Locomotives on Hump

3 Units—1200 hp each.

Equipped with slow-speed speedometers.

[The film was then shown].

Chairman Krefting: Mr. President, this concludes the report and special feature of this committee.

President Woolford: Thank you, Mr. Krefting, for the effective way you have carried forward the work of Committee 14 during the past year, and for the interesting and informative reports presented by your committee. And thank you, Mr. Brisbin, for presenting to us the interesting motion picture of your road's new retarder yard near Youngstown. I am sure you can be proud of this facility.

Mr. Krefting, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Economics of Railway Location and Operation

[For report see pp. 243–258.]

[President Woolford presiding.]

President Woolford: The next committee to report is Committee 16—Economics of Railway Location and Operation, the chairman of which is R. L. Milner, transportation assistant, Chesapeake & Ohio Railway, Huntington, W. Va. I will be pleased if Mr. Milner and the other members of his committee will come to the platform at this time and present their report. Again, I especially invite those subcommittee chairmen who are to make reports to take their places here at the speaker's table, as close as possible to the podium. Of course, gentlemen, if time permitted, we would invite you to give discussion from the floor. However, we are now about 25 min behind schedule, so I'm afraid we will have to eliminate that discussion.

Mr. Milner, I would like to turn the podium over to you and ask you to make your report.

Chairman R. L. Milner: Mr. Chairman, members of the Association, and guests:

Your committee is reporting on 4 of its 11 assignments. These are presented on pages 243 through 258, Bulletin 553. One of these is a final report, three are progress reports, all are submitted as information. Your committee invites your comments regarding its presentations and will be glad to reply to any questions raised thereon.

Assignment 1—Revision of Manual.

Chairman Milner: A. S. Lang, assistant professor of transportation engineering, Massachusetts Institute of Technology, subcommittee chairman, will present the report on Assignment 1.

A. S. Lang: Mr. President, members: Your committee is submitting this report as information only:

About three years ago this subcommittee undertook to rewrite the section of Chapter 16 relating to motive power. As this work progressed, it became increasingly apparent that there was serious overlap between this material and the material in other sections of the Chapter. This difficulty finally impelled the subcommittee to undertake a critical review of the organization of the entire chapter.

The subcommittee's conclusion, reached about a year and a half ago, was that the entire chapter needed reorganization. In its present form the Chapter is the consolidation of two previous chapters. Material has been added here and there throughout the years, so that the original plan has long since been obscured.

As a result, an entirely new chapter outline has been prepared and subjected to the criticism of the full committee. This outline has now been published in Bulletin 553 by way of inviting comment from the full Association membership. Work has begun on the preparation of the detailed text material to follow this new outline. This will incorporate most of the material in the present chapter, but it will be in greatly altered

form. The first of this new text will be presented for your approval at next year's convention.

It is our earnest hope that this job will be completed in time for the next major printing of the Manual in 1962. Because of the magnitude and the difficulty of this task, however, we are extremely anxious to get any such comments and criticisms as the Association membership may care to make either now or in the future.

PRESIDENT WOOLFORD: Thank you Professor Lang. Your report will be received as information.

Assignment 2—Effect of Degrees of Curvature on Cost of Track Maintenance, Collaborating with Committees 4 and 5.

CHAIRMAN MILNER: Assignment 2 is under the direction of L. P. Diamond, assistant engineer research, Chesapeake & Ohio, Huntington, W. Va.

The original plan for this study is based on analysis of five major items of expense: ties, rails, other track material, ballast and track laying and surfacing. An extended report was made at last year's convention and is included in the Proceedings for that year. The major unfinished portion of the report related to rail. The subcommittee felt it desirable to revise and elaborate upon certain aspects contained in the tentative final draft. Completion is expected in 1960.

Assignment 3—Determination of Maintenance of Way Expenses for Various Traffic Volumes, Collaborating with Committee 11.

CHAIRMAN MILNER: This subject is being handled by a subcommittee of which H. B. Christianson, Jr., Assistant to Vice President—Operations, Chicago, Rock Island & Pacific Railroad, Chicago, is chairman.

A number of progress reports have been made on this assignment in previous years under the direction of J. P. Ray, who retired last year as regional engineer, Baltimore & Ohio. Mr. Ray, though still a member of this committee, retired from the chairmanship of the subcommittee. An extended report has recently been submitted to subcommittee members outlining test results of some very comprehensive regression analyses of maintenance of way and structures expense. The interpretation of results are now being reviewed.

Assignment 4—Potential Applications of Electronic Computers to Railway Engineering and Maintenance Problems in Design, Inventory, etc., Collaborating with Committees 11 and 30, and Informally with the Railway Systems and Procedures Association.

CHAIRMAN MILNER: Ferdinand Wascoe, manager, Bureau of Transportation Research, Southern Pacific Company, San Francisco, Calif., is chairman of the subcommittee handling this subject.

An extended report was presented last year which outlined the organization and use of computers, types of computers available, with elaborate descriptive data and costs of equipment, applications of computers to engineering problems relating to problems in soil engineering, cut and fill computations, and structural and mechanical engineering.

In December 1959, your subcommittee forwarded a questionnaire to Class I Railroad engineering departments asking for a listing of existing and anticipated programs applicable to engineering problems. The results, although incomplete at this time, are being analyzed. It is hoped that this information can be indexed and maintained on a continuing basis, either in the form of actual programs or general problem and program

descriptions at some central point for ready reference by all railroads. Publication of one or more example programs in the Manual will then complete this assignment, with the recommendation that a standing subcommittee be established to keep the index up to date.

Assignment 5—Methods of Reducing Time of Freight Cars Between Loading and Unloading Points, collaborating with Car Service Division, AAR, Signal Section, AAR, Operating-Transportation Division, AAR, and American Association of Railroad Superintendents.

CHAIRMAN MILNER: George Rugge, assistant engineer, Atchison, Topeka & Santa Fe Railway, Chicago, is chairman of the subcommittee handling this subject.

An extensive outline has been completed on this subject, which is to be followed in working up related portions of the overall assignments. Our subcommittee expects to have a progress report ready for our next meeting in June.

Assignment 6—Economics of Improved Freight Stations and Facilities, Collaborating with Committees 6 and 14, and Freight Station Section, AAR.

CHAIRMAN MILNER: The report on Assignment 6 will be presented by Subcommittee Chairman, T. D. Wofford, Jr., engineer of design, Illinois Central.

T. D. WOFFORD, JR.: Mr. Chairman, members and guests of the Association:

Your committee is presenting a final report on Economics of Improved Freight Stations and Facilities. The report has been published in Bulletin 553 beginning on page 247.

In recent years there have been impressive developments in new equipment and new methods of operating freight stations. These offer interesting possibilities from an economic viewpoint both for improvement of existing freight houses and for construcing new facilities. However, the total volume of LCL business on American railroads continues to decline, and this has had an important bearing on plans for new facilities.

A new mode of transportation, the trailer on flatcar, has made its appearance in recent years and has already influenced the economics of freight stations and facilities. At this time piggyback operation is increasing at an impressive rate.

The amount of LCL traffic handled in boxcars, the growth of piggyback and other factors brought out in the report greatly affect the economics of improved freight stations at the present time. The report now submitted is an appraisal of the current situation.

Your comments or questions relating to this topic are invited.

PRESIDENT WOOLFORD: Thank you Mr. Wofford.

Assignment 7—Engineering, Maintenance and Operating Benefits to Be Derived from Increased Joint Use of Railway Facilities, Collaborating with Committees 11, 14 and 20.

CHAIRMAN MILNER: Our next report, on Assignment 7, will be presented by Subcommittee Chairman J. W. Barriger, president, Pittsburgh & Lake Erie.

J. W. BARRIGER: Mr. President, Mr. Chairman, members and guests. Your committee submits a progress report as information containing examples of negotiation principles and the benefits which accrue from coordinated use of railway facilities. We again wish to emphasize the urgent necessity for continued exploration in this field, with the ultimate goal of eliminating duplicate facilities and reducing operating expenses. There must be a huge number of such possibilities which can be accomplished through

cooperative study with your neighbors and competitors, to the ultimate advantage of the participants. We expect to follow with other reports of interest to those companies that are investigating coordination. If there are any questions, we will be pleased to have them presented for discussion.

PRESIDENT WOOLFORD: Thank you Mr. Barriger. Your report will be received as information.

Assignment 8—Innovations in Railway Operations.

CHAIRMAN MILNER: The report on Assignment 8 will be presented by Subcommittee Chairman A. L. Sams, principal assistant engineer, Illinois Central.

A. L. SAMS: Mr. Chairman, members and guests:

The report on Assignment 8 this year deals with the operation of suburban passenger trains. Although urban and suburban population is growing, thereby increasing the traffic potential of a commuter line, competing forms of transportation are drawing off all of the increase. We suggest this can be overcome by a reduction in expenses by the automation of operating procedures.

The committee recognizes that the proposal presents serious problems that must be met and solved. However, suburban lines are serving a useful function, which will become more important as population increases, and every effort should be made to assure their continued operation.

This is a progress report, presented as information.

PRESIDENT WOOLFORD: Thank you Mr. Sams. Your report will be so accepted.

Assignment 9—The Effect of Equated Mileage and Traffic Funds for Maintenance of Way Operations on Main and Branch Lines.

CHAIRMAN MILNER: J. W. Bolstad, chief engineer, Fort Dodge, Des Moines & Southern Railway, Boone, Iowa, is chairman of the subcommittee handling this subject.

The subcommittee is endeavoring to develop some type of formula or equation which will duly recognize the effect of equated mileage and traffic tonnage. To date, Committee 16 has been circularized to furnish information as to present uses of equated mileage data. The findings so far indicate that equated mileage is used very sparingly and then usually confined to special problems. Many equated mileage tables are designed for use on labor distribution with little consideration of traffic tonnage. A table of this type now appears in the AREA Manual in Chapter 22—Economics of Railway Labor. This type of table was not found applicable to the study being made by Subcommittee 9. The next step will be to try revising existing tables to reflect equated mileage for various traffic densities. At least one suggestion has been made that gradient and alinement also be considered.

Assignment 10—Methods of Minimizing Cost of Construction and Maintenance of Industry Tracks to Improve the Competitive Position of Railways, Collaborating with Committee 11, and with the Law Department, AAR.

CHAIRMAN MILNER: Bruce Miller, regional engineer, Pennsylvania Railroad, Cincinnati, Ohio, is chairman of this subcommittee, which has developed an extensive report covering influences of laws and practices pertaining to industry sidings, construction and maintenance, out-of-pocket costs of construction and maintenance, methods of financing and accounting practices. The report is practically complete except for moderate revisions suggested at the last committee meeting. The subject is to be completed for 1961.

Assignment 11—Review of Developments in New Methods and Modes of Transport.

CHAIRMAN MILNER: F. J. Richter, Publisher, Modern Railroads, Chicago, is chairman of this subcommittee.

The subcommittee plans to follow up its report on the economics of transporting suspended solids by pipeline with two other economic reports. One is to be on the economics of monorail transportation in the light of improved technology that affects monorail design. The other is the nature of and possible potential of vehicles operating with a layer of compressed or induced air between the vehicle's bottom surface and the ground. This development already carries such designations as Levapad and Air-Car. Considerable developmental work on the air-ride vehicle has come to light in the past year, both in the United States and abroad.

This principle of propulsion has the potential advantages of overcoming ground friction and simplifying the roadway requirements. It does bring with it problems of guiding the vehicles and also controlling them against sudden gusts of cross winds. In both instances, the use of some rail-guiding mechanism, similar to railroad track, could overcome that handicap.

With respect to the monorail development, increased interest is being shown in it by some groups concerned with metropolitan transit problems. This subject, too, is being pursued under Assignment 11.

Mr. Chairman, this concludes the presentation of reports by Committee 16 covering work of the past year. Our program includes one additional presentation. Our committee has wholeheartedly endorsed the greater emphasis stressed by the Association on the broader aspects of committee work, particularly through reliance upon special presentations to highlight assignments. As the committee on "Economics of Railway Location and Operation," our assignments relative to economics in maintenance and construction, have, over the years, been interspersed with studies on the economic influences, or aspects, of types of power, train-hour costs, train service and performance, location and spacing of facilities, coordinated transportation and special services, and so on.

Thus, Committee 16 felt it important to direct attention to the relationship and to its interest in both railway engineering and railway operation. For this reason, our committee prevailed upon the Atchison, Topeka & Santa Fe to let us place on exhibit in the mezzanine their model of the Abra–Skull line change in Arizona.

Our speaker today epitomizes in the most objective way the practical resolution of the type of studies assigned to our committee. He has had extensive service in both the engineering and operating departments, serving as vice president—construction and maintenance, prior to attaining his present position as vice president—operations, Chesapeake & Ohio Railway. Mr. M. I. Dunn.

Operating Innovations—Present and Future

By M. I. Dunn

Vice President—Operations, Chesapeake & Ohio Railway Company

In this day and age we are prone to take for granted accomplishments which were unheard of just a few short years ago. We were greatly impressed when the first satellite was blasted into orbit, but with each succeeding space shot our amazement lessens. Today we are accustomed to the everyday happenings of the "space age", and these space shots no longer impress us as they once did. The accomplishment of the extra-

ordinary no longer impresses us—we are only impressed by the attainment of the so-called "impossible".

What significance do these achievements have in relation to the railroad industry? There is the very obvious lesson that technology as a whole is progressing at an unprecedented pace. In order to survive and progress, we of the railroad industry must keep abreast of and adopt technological advances in our efforts to provide better, more efficient and more economical transportation services that the public demands to the exclusion of agencies that do not provide such services. The past is history—we must look to the future, for there lies our success or failure.

There are problems peculiar to each of the various segments of the complex transportation network of this country. Much has been said—and a little has been done—about the inequality of the restrictions under which railroads labor. If given a fair break against subsidized competition, the railroads would improve their volume in their basic job of moving freight. However, such relief is certainly not the complete answer. What good purpose would less restrictive legislation serve in the long run if railroads continue to try to compete utilizing outmoded equipment and yesterday's operating and maintenance techniques?

To find funds for modernization of equipment and plant is becoming more difficult, but we must not take a defeatist's attitude. Instead, we must think smarter and work harder to the end that, even though we might never be able to completely throw off the burden of subsidized competition, we will nevertheless survive and progress in spite of it.

Railroads have only recently begun to grasp new concepts of operation. From a technological standpoint, the attitude "There will always be the railroads", is far from realistic, but with the development of better technology and operating techniques, much may be accomplished.

The greatest single accomplishment to date has been dieselization. The C&O, in common with most American railroads, is completely dieselized. Considering the impact of dieselization, it is interesting to conjecture what our costs would be today if our motive power consisted of steam rather than diesel. An educated guess is that if C&O's power in 1959 had consisted of 100 percent steam, our fuel and locomotive repair costs alone would have been $25 to $30 million higher. Crew costs, utilization of cars and lack of flexibility under steam operation could well have doubled the total. What C&O, a coal carrier belatedly accomplished is typical of the industry, but the industry has not carried this saving through to net on an industry-wide basis. We were running fast to stand still against the current of increasing labor and material costs.

You know that we of the railroad industry have been accused of living in the past, operating under outmoded conditions, utilizing methods and equipment developed many years ago. In the eyes of much of the public, we have only recently begun to throw off the yoke. We may have been operating satisfactorily by the standards of yesterday; nevertheless, we should remember Thomas Edison's admonition, "There is a better way—find it."

This is the most important task facing operating officers today—finding the better way. We can do a lot of little things which add up in this effort to run fast enough to not only stand still, but to make headway against the tides of adversity.

Let me show you some of the things C&O is doing. Perhaps you have found better ways. Certainly we must all try to find the better way if we are to survive.

In 1957 C&O began operations of its Car Location Information Center—CLIC for short—a coast-to-coast teletype network.

[Slide*—showing map of traffic offices, with its nerve center in Huntington, W. Va.] Through CLIC, each of our freight traffic offices from coast to coast, from Canada to Florida, receive up-to-the-minute teletype information on the location of all cars shipped from or consigned to its territory.

[Slide—showing route of train.] This slide gives you an idea how CLIC works. As a train leaves Newport News, Va., information on all cars in the consist is relayed to CLIC in Huntington and to the next division point—Richmond. Special instructions such as reicing, feeding of cattle, etc., are included in the information relayed.

[Slide—showing clerk at teletype.] The yard installation includes teletype machines for both receiving and sending.

[Slide—showing what report looks like.] This is what one of the teletyped messages looks like. All essential movement information is included in the report.

[Slide—System relay office.] The consists are received here—the system relay office serving CLIC in Huntington. This office is the focal point of the communications network. Here, the consists are relayed into CLIC.

[Slide—CLIC.] This is CLIC, where information is received on perforated tape and in printed form. The tape is converted into punch cards. Cards are sorted mechanically and the "first-reported" cards are reconverted to tape for transmission through the relay office to traffic offices. A record of all car movements is kept in this office. Within minutes CLIC can tell a patron where his car is located.

[Slide—System relay office.] To send the information to the traffic offices, the message again goes through this system relay office. The employees here are feeding transmission tape into the transmission equipment.

[Slide—Traffic office.] Within minutes, the information is received in each of the traffic offices concerned. This is the information that patrons want.

CLIC is an important service to shippers—a service that was installed before the shippers realized they even needed it. Now our patrons say that they can't get along without it!

As of now, CLIC reports only the movement and whereabouts of merchandise traffic. Soon it also will be doing the same job for coal. A car distribution system based on information available in CLIC enables C&O to get greater utilization of all its cars. Through the system we are able to have cars at the right places at the right times.

This improved car distribution makes it possible to do the job with fewer cars. Today, the average railroad freight car travels only 2½ hr a day for a total of 50 to 60 miles. Through CLIC we know that the average daily mileage of cars will be increased substantially.

C&O also was the first railroad to use an electronic digital computer—Univac. [Slide—showing computer center.]

Univac is an important part of our data processing system. [Slide—showing Univac chart.]

Information from field offices in Huntington, Richmond, Cleveland and Detroit is sent to Univac and used for paying employees and shareowners, paying other railroads

* The slides shown by Mr. Dunn are not reproduced herein.

their divisions on interline freight shiipments, settling per diem and car mileage, and providing management with up-to-the-minute reports, and reducing the cost of paper work.

While all these jobs are important, we see Univac teaming up with CLIC for some even more important jobs—helping us get more work out of power and cars. Performing with speed and accuracy never before possible, Univac is opening opportunities for cost saving in eliminating some of the billions of paper documents generated annually.

Most of these innovations have come about in our efforts to retain or increase the life blood of our business traffic. They are important only to the extent that they have resulted in improved service to customers, thereby strengthening the railroads' competitive position with other forms of transportation.

Improved service is being provided through new cars, new equipment and new thinking. In recent years railroads have developed [slides]:

Electronic push-button yards where speed of impact is radar controlled, such as our recently completed Fitzpatrick Yard at Russell, Ky.

Coil steel cars.

Compartmentizer cars.

Damage free loaders.

Piggybacking.

Piggyback on passenger trains.

New automobiles via piggyback. (This is an encouraging innovation. Auto companies are intensely interested in this development.)

Cars made over especially to handle specific items, such as rear-end auto assembly cars.

Flexivans.

Railvan, the C&O-developed "box car" that moves on both rails and highways. Here you see Railvan in actual operation, on the end of a passenger train. Presently it's being used to carry mail and express. It has two sets of wheels—rubber tires for highway use and regular steel-flanged wheels for rail use. On arrival at destination the Railvan is taken off the train and, in a matter of minutes, attached to a tractor.

Centralized traffic control. At the present time, C&O has CTC installed on 2,066 miles of track.

Hot box detectors. There are 13 detectors in service presently on the C&O at various points on the line and at entrance to yards. More will be installed. These devices forestall accidents by detecting hot boxes before they become critical.

Of course, in this area the prime objective is to eliminate hot boxes—not just to detect them. We all know that roller bearings are an effective cure, but with a price tag of $80 million in our case "rollarizing" just isn't an economic answer to the problem. Improved packing devices applied to standard bearings are not accomplishing what was hoped for by their proponents. Some optimism may be voiced with respect to the various types of sleeve or cartridge bearings now undergoing tests, but the main hope therein is that a successful sleeve bearing will bring down the price of roller bearings.

The foregoing are innovations of the present. What of the future?

Designers and dreamers have many ideas on their drawing boards. We hear talk of atomic-powered locomotives; remote-control trains, operating at fast speeds over unsignaled plastic rails; controlled by electronics.

Fantastic, pie-in-the-sky ideas? Who can say that anything is fantastic in this age of orbiting satellites and rocket-to-the-moon expeditions?

Who can know for certain what tomorrow will bring? By tomorrow, perhaps even the ultra-modern electronic freight yards will be made obsolete by piggyback techniques and containerization. Piggybacking is growing so fast that no one can tell where it will be 10 years from now. It is envisioned that a filled container will come off the end of a factory's production line and, automatically, be lifted, loaded, moved, sorted, lifted again, etc., as it moves along to the break-bulk point of its trip.

But these things are not immediately of the future. The physical facilities necessary for the exploitation to the maximum of the vast potential of the railroad industry are designed and installed by forward looking, capable engineers such as yourselves. The present offers rare opportunities for such of you who accept the challenge.

I would like to point out a few areas in which it appears to me we should innovate.

Diesels, capable of operating much greater distances without the pampering necessary in the operation of steam locomotives, together with centralized traffic control, should enable us to increase the length of runs, and, at the same time, afford faster, safer more economical operation of trains. The chief obstacles to thereby eliminating a large number of our intermediate terminals altogether lie in antiquated labor contracts, the form and substances of which were based on steam operation. With, and largely because of these rules, together with train order dispatching, the pattern of the railway division was set up . . . two, three or four 100-mile train districts. Each division had a staff complete with officers whose authority was limited to the division. Measured in time to traverse the division, its length could be as much as twenty-four hours in the case of a freight train. Today it is half whatever it was when the rules were written. Tomorrow, with longer crew runs, it could be a few hours.

Why not create centralized dispatching bureaus in this day of centralized traffic control, and eliminate divisions as we know them in favor of regions, districts—call them what you will—supervised by a manager?

In maintenance of way, would it not be practicable to design a track reconditioning train which would, in one operation, lift track, remove and replace worn-out ties, plow out foul ballast, pick it up and screen it and deposit it back underneath the ties?

As you well know, continuous rail affords many opportunities for cost reduction, principal among these being the elimination of angle bars and bolts and the elimination of that old headache, rail-end maintenance.

This, of course, calls for new methods of handling; for example, new methods to transport the long strings of rail from welding point to point of installation.

There is a way to reduce this cost of handling—do the welding on the job. This has been done successfully; however, the overall cost has not been significantly reduced.

How about getting the benefits of continuous rail by laying rail with conventional joints, but with absolutely no expansion provision, adding, of course, the extra rail anchors and full ballast section that go with continuous welded rail? This has been done successfully with all the benefits of welded rail and at much reduced cost.

I have long been a proponent of diversification in the railroad industry, and am optimistic as to our chances of evolving into integrated transportation systems. Diversifi-

cation, which would allow railroads to operate not only on rails, but in the air and on water, would provide opportunity for the railroads to expand and become transportation companies.

We stand at the crossroads today. Will railroads, can railroads, survive under free enterprise? I believe they can and will. I venture that before too many years have passed, some of the "futuristic" ideas which I have touched on will become commonplace.

We must be steadfast in our belief that the railroads have a shining future. Without optimism as to our chances of survival, and ambition and drive to improve, we shall only be playing out a losing game.

Thank you. [Applause]

Chairman Milner: Thank you, Mr. Dunn. It has been a real privilege to hear your inspiring talk. It is indeed encouraging to have spelled out so clearly the problems facing the railroad industry in general and railroad engineers and management in particular; also the opportunities or avenues which are available for solution, which may include innovations in methods or facilities, or may rely upon integration of transportation agencies as outlined in your talk today on Operating Innovations—Present and Future.

Mr. President, this concludes our committee report. It also concludes my three years as chairman. I am grateful to all members of Committee 16 over the past three years for the fine work done and for the support given me. I am sure that this will be continued in the future under our new Chairman, C. L. Towle, chief engineer, Detroit, Toledo & Ironton Railroad, and our coming vice chairman, T. J. Lamphier, director of economic research, Great Northern Railway.

I also want to thank President Woolford, Secretary Howard, and past Presidents McBrian and Meyers for their advice and support.

President Woolford: Thank you, Mr. Milner, and members of your committee for your work during the past year and for the important reports which you have presented; and thank you, Mr. Dunn, for your challenging address with respect to railroad operating innovations. Under its assignment dealing with innovations in railway operations, Committee 16 has not overlooked this important matter, but I am sure the committee has been stimulated by your address to still further intensive research and study to develop and promote new and more efficient means of operation.

And my special thanks to you, Mr. Milner, for the able and dedicated leadership which you have given to Committee 16 for the past three years. As you lay down your responsibilities as chairman, we are pleased to welcome as your successor, Mr. Towle, and as the new vice chairman of your committee, Mr. Lamphier. We are satisfied that under their direction the good work of your committee will continue..

Your committee is now excused with the thanks of the Association. [Applause]

Gentlemen, as you note, we are running a little late. I have asked F. J. Olsen, the vice chairman, in the absence of Chairman J. F. Piper of Committee 25, if he would agree to put off his presentation until tomorrow morning, and he has consented.

Before adjourning the meeting for today, I would like to announce that J. E. Wiggins, Jr., engineer of water supply of the Southern Railway System, has been appointed by your president as chairman of the Tellers' Committee to canvass the ballots cast for the officers of the Association for the coming year. The ballots will be counted in the Gold Room on the first floor tomorrow morning, beginning at 7:00 a.m. or shortly thereafter, looking to announcing the names of the successful candidates at our Annual Luncheon tomorrow noon.

You will be interested to know that the convention registration up until 3:00 o'clock today included 621 railroad men and 383 guests, a total of 1004.

The meeting is now adjourned, to convene tomorrow morning at 8:30 am sharp—and I emphasize the 8:30, gentlemen—in the George Bernard Shaw Room, which is one floor below the lobby level, near the Randolph Street entrance to the hotel.

[The meeting recessed at 5:40 pm.]

Tuesday Morning Session—March 15, 1960

[The meeting convened at 8:30 in the George Bernard Shaw Room, President Woolford presiding.]

President Woolford: Gentlemen, we are a little behind time. We hope to catch up this morning and be on time this afternoon. The meeting will please come to order. This is the earliest, I believe, that we have ever begun a convention session, but it is essential that we adopt an 8:30 start in order to accommodate our lengthy and intensive program designed to be of maximum benefit to all.

Discussion on Waterways and Harbors

[For report see pp. 307–330.]

President Woolford: The first committee to report this morning will be the committee we had to miss yesterday afternoon—Committee 25—Waterways and Harbors. J. F. Piper, assistant chief engineer—construction, of the Pennsylvania Railroad, is chairman of this committee, but since it is impossible for Mr. Piper to be present here today, the committee's presentation will be made under the direction of Vice Chairman Frank J. Olsen, resident engineer, Baltimore & Ohio Chicago Terminal Railroad. If Mr. Olsen and the other members of his committee will come to the platform promptly, we are prepared to hear their report.

While the committee is coming to the podium, gentlemen, I want to remind you that although we are short on time, we still would like to have comments from the audience. If there are any points about the meeting or in the discussion that you want to bring up, feel free to say whatever you think.

Vice Chairman Frank J. Olsen: Mr. President, honored guests, and members of the Association:

Due to the change in program, we have lost most of our subcommittee chairmen, but at this time I would like to introduce the only subcommittee chairman that we have with us today—the chairman of Subcommittee 6, G. W. Benson, division engineer, Central of Georgia.

Assignment 1—Revision of Manual.

Vice Chairman Olsen: The material in our Chapter of the Manual is of such character that revision at this time is not indicated.

Assignment 2—Current Policies, Practices and Developments Dealing with Navigation Projects, Collaborating with AAR Committee on Waterway Projects.

Vice Chairman Olsen: There have been no specific changes during the current year on the practices or policies of the Corps of Engineers in the handling of Waterway

Projects. This committee's work will be expanded during the coming year. It will collate and edit material from various sources for printing in the Bulletin for the information of the Association.

Assignment 3—Bibliography Relating to Benefits and Costs of Inland Waterway Projects Involving Navigation.

Vice Chairman Olsen: At this time I would like to call on G. W. Becker, special engineer—drainage, Rock Island, to give the report on Assignment 3 in behalf of the subcommittee chairman, M. A. Michel, assistant to chief engineer, Pittsburgh & Lake Erie.

G. W. Becker: Mr. President, Mr. Chairman, honored guests, and members of the AREA: Under Assignment 3 the Bibliography Relating to Benefits and Costs of Inland Waterway Projects Involving Navigation is currently being prepared in annotated form, with the thought that the reader may discern whether or not he is interested in the volume, or report, annotated.

Annotations, in Vol. I of the Hoover Task Force Report, dated June 1955, on Water Resources and Power, direct attention to: "Principles to Be Applied in Determining Economic Justification of Water Resources and Power Projects and Programs", pointing out that due consideration should be given to such *Negative Benefits* as "Adverse Effects on Alternate Means of Transportation or on Other Communities", and they should be included in the economics of the projects. Appendix "N" (Vol. II): "The Lake Erie–Ohio River Canal Project", indicates the importance of the first and only ICC investigation of a federal report for a proposed navigation project (No. 235 ICC dated October 3, 1939); wherein, it was determined that the railroads which had ample time and terminal capacity to handle any and all prospective traffic could ill afford to suffer a "gross revenue loss of 35 million dollars or more annually" (100 million in 1959).

The Federal Interagency Committee "Green Book", May 1958, also handles "Consequential Damages" as a measurement to be considered in benefit to cost evaluation with the following: "Uncompensated Adverse Effects are costs of a project and should be treated in the same manner as other costs are treated for purposes of economic analysis". This is very much on the order of the Hoover Task Force Report statement regarding negative benefits.

As the Special Select Senate Water Resources Committee has been recently holding Public Hearings, in regard to Proposed Federal Water Projects, it is of interest to note that Dr. Edward Ackerman will prepare a multipurpose river management report for that Senate Committee.

This is the same Dr. Ackerman who co-authored "Technology in American Water Development" (which has been reported in annotated form), wherein, he directed attention to the fact that the absence of the Lake Erie–Ohio River Canal (among other vital inter-basin connections) precludes possible operational economies which would be afforded by a large-scale navigation system connecting the centers of origin and destination of heavy traffic.

The committee will continue to progress its annotated bibliography relating to benefits and costs of waterway projects involving navigation.

Assignment 6—Planning, Construction and Maintenance of Rail-Water Transfer Facilities.

Vice Chairman Olsen: The progress report on car transfer facilities, submitted as information at the 1959 convention, is receiving further study, and it is expected that additional progress will be made and reported in the future.

Assignment 7—Relative Merits and Economics of Construction Materials Used in Waterfront Facilities.

Vice Chairman Olsen: Now J. E. Inman, assistant engineer, Santa Fe, will present the report on Assignment 7 in behalf of the subcommittee chairman, Dr. Shu-t'ien Li, consulting engineer.

J. E. Inman: Mr. President and members of the Association:

Your committee submits as information the following report of progress.

1. Criteria of Relative Merits of Construction Materials Used in Waterfront Facilities on the Basis of Inspection, Tests, and Service Performance Records—These criteria were published in Bulletin 539, November 1957. They have been under continued study, and will be edited and submitted for adoption as recommended practice in the latter part of 1960. Comments on these criteria from the entire membership are invited.

2. Criteria of Comparative Economics on the Basis of Annual or Capitalized Cost Methods—These criteria were also published in Bulletin 539, November 1957. They have been likewise under continued study, and will also be edited and submitted for adoption as recommended practice in the latter part of 1960. Comments on these criteria from the entire membership are invited.

3. Annotated Bibliography on Relative Merits and Economics of Construction Materials Used in Waterfront Facilities—A comprehensive annotated bibliography on this subject has been planned by your committee, and a modest request for funds to carry out the study has been made to the Board of Direction.

4. Greenheart, Its Outstanding Merits, Properties, and Economics in Waterfront Facilities—Comprehensive research on this subject has been undertaken by Dr. Shu-t'ien Li, chairman of the subcommittee. The appended paper on the subject constitutes the first complete unit and is submitted herewith for information.

A further report on greenheart forthcoming in the ensuing year will include:

1. Source and production of genuine greenheart;
2. Case histories and specific service performance records of greenheart;
3. Design criteria and examples for greenheart piling, decking, and fendering; and
4. Specifications for greenheart construction.

President Woolford: Thank you, Mr. Inman. Your report will be received as information.

Vice Chairman Olsen: Under its assignments for the coming year, your committee will begin a study of the new facilities serving the Great Lakes and the St. Lawrence Seaway, a subject of growing interest in view of the rapid expansion and development of Great Lakes ports.

It will also begin a study of the best methods for specific commodity handling.

This concludes Committee 25's report.

President Woolford: Thank you, Mr. Olsen, for the reports on two of the assignments of your committee, and for the work which I know is under way on your other assignments. The report intended to be presented by Dr. Li was most ably presented by a member of the subcommittee. The committee is to be commended for the comprehensive and informative report presented on Greenheart timber for use in waterfront facilities. This report is a classic in factual research, which I know will be referred to many times by engineers, both on and off the railroads.

We sense a definite resurgence of interest in the work of your committee during the past year under the direction of Chairman Piper, which I am sure will continue in the year ahead and be reflected in the future reports of your committee.

We thank you, Mr. Olsen, for pinch-hitting for Mr. Piper. Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Water, Oil and Sanitation Services

[For report see pp. 283–306.]

[President Woolford presiding.]

President Woolford: The next committee to make its report this morning is Committee 13—Water, Oil and Sanitation Services, the chairman of which is D. C. Teal, superintendent of water supply—system, Chesapeake & Ohio Railway, at Richmond, Va. Will Mr. Teal and the other members of his committee please come to the platform promptly and proceed with their presentation.

While the committee is coming to the platform, I would like to remind you that we have manned microphones in the aisles which will be brought to anyone wishing to comment from the floor.

At our sessions today, as yesterday, I will appreciate it if all reporting subcommittee chairmen of the various committees will take their places here at the main speaker's table, as close to the podium as possible, in order to save time in presenting their reports. With these brief comments, I will now turn the microphone over to Chairman Teal.

Chairman D. C. Teal: Mr. President, members of the Association, and guests:

The report of Committee 13 is found in Bulletin 553, pages 283 to 306, incl. Our 12 assignments cover a variety of subjects. To save time, I shall comment briefly on the subjects that are being presented as information and shall ask only the chairmen of subcommittees with Manual material to come to the podium. You are invited to interrupt at any time with questions or comments.

Assignment 1—Revision of Manual.

Chairman Teal: Under Assignment 1, no revisions are proposed this year. Extensive review of Parts 5, 6, and 7 of Chapter 13 has been scheduled for the coming year, this in compliance with the understanding that all Manual material should be brought up to date by 1962.

Assignment 2—Prevention of Corrosion in Hot and Cold Water Systems.

Chairman Teal: The efforts of Subcommittee 2 were concentrated during the past year on revising previously published information reports concerning corrosion in steam and condensate lines into a statement of recommended practices. Its report has been accepted by Committee 13 and is believed ready for inclusion in the Manual. I would like at this time to call on J. J. Dwyer, chief chemist, Chesapeake & Ohio, chairman of the subcommittee, who will present this report. Mr. Dwyer.

J. J. Dwyer: Mr. President, Mr. Chairman, and members of AREA:

The report I shall discuss appears on page 285 of Bulletin 553 for November 1959. A year ago we presented a report entitled "Prevention of Corrosion in Steam and Condensate Lines." That information was relatively new, and was unheard of a few years before. In previous years we had had ways of treating boiler feedwater, and thus of protecting boilers from corrosion. But the boiler-water chemicals did not carry over with the steam, and since the steam condensate was usually acid in nature, it wrought havoc with the condensate systems. The only protection then available was to build the condensate return systems according to the best mechanical designs known, using the best and heaviest materials, and thereafter replace piping as the acid condensate destroyed it.

A few years ago a new chemical treatment was discovered, which is volatile in the steam leaving the boiler, and which then condenses with the steam. There are two types of this treatment, known as "neutralizing amines" and "filming amines." The first protects by neutralizing the acid in the condensate, and the other protects by forming a non-wettable film on the inside pipe surface to keep the corrosive acid condensate from coming in contact with the metal. Both types are therefore useful, and which type to use is governed by the economics involved. Our report of a year ago covered this topic in considerable detail.

After this report was completed and presented a year ago, it was the unanimous opinion of the committee that this was valuable information which should be incorporated into the Manual if it could be reworked into suitable form. Our tentative 1960 subject entitled "Prevention of Corrosion in Hot and Cold Water Systems" was therefore postponed, and Subcommittee 2 was assigned the task of restudying and condensing the previous report into a form suitable for inclusion in the Manual.

In our current report, with the turned-around title "Corrosion Prevention in Steam and Condensate Lines", you will find the condensed version of the subject which the committee feels should be useful to the engineering profession as recommended practice. Mr. President, I therefore move that this new report, entitled "Corrosion Prevention in Steam and Condensate Lines" be adopted for inclusion in the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 3— Design, Construction and Operation of Coach-Servicing Facilities to Comply with Regulations of U. S. Public Health Service, Collaborating with Joint Committee on Railway Sanitation, AAR.

Chairman Teal: Our progress report on Assignment 3 has to do with coach watering hydrants. It is no secret that a large percentage of hydrants now being used for watering passenger coaches are considered unsatisfactory by the United States Public Health Service. The railroads are under more or less constant pressure from the Public Health Service to replace these with approved hydrants.

It is also the consensus of railroad people concerned that the coach-watering arrangements now approved by the U. S. Public Health Service are in most cases expensive to install and maintain and are generally unsatisfactory as far as the railroads are concerned.

It follows that the design or development of a coach-watering hydrant that will be acceptable to the U.S.P.H.S., economical to manufacture, require a minimum amount of maintenance, be practical in cold climates and otherwise satisfactory to the railroads, will greatly benefit the industry.

In progressing the assignment, a mass of data was collected, consisting of blueprints and pictures of coach-watering hydrants now in use. It was found that the proper evaluation of the data collected requires time and application of engineering skills that the committee does not command. Last June we referred this matter to G. M. Magee, director of engineering research, AAR, proposing an allocation of $15,500 for a research project. This request was subsequently considered by the AREA Board of Direction and others concerned, and we were notified in late 1959 that the sum of $2,000 would be included in the 1960 AAR Research Budget for a preliminary study. We have accordingly turned over all information available to Mr. Magee and his staff.

Assignment 4—Cathodic Protection of Pipelines and Steel Storage Tanks, Collaborating with the Electrical Section, AAR.

Chairman Teal: This is a subject Committee 13 has been studying for several years. The report prepared by the subcommittee this year encountered differences of opinion within the committee, and its publication has been withheld pending reconciliation of these differences and the approval of the collaborating section.

Assignment 5—Transportation of Solids by Pipelines, Collaborating with the Pipeline Division, ASCE, and Other Interested Organizations.

Chairman Teal: Our short report on Assignment 5 consists of a description of recent installations, together with bibliographical data and the recommendation that this subject be discontinued. It has been found that each project of this nature is a special problem, with no two alike. Also, what might be entirely feasible from an engineering standpoint may not be economically worth considering. In many cases, the cost of preparing the material for transportation and for use at the end of the line will be greater than transportation costs by other methods. In most cases, a pipeline for carrying solids is economical only where large quantities and relatively long distances are involved.

Assignment 6—Railway Waste Disposal, Collaborating with Joint Committee on Railway Sanitation, AAR.

Chairman Teal: Our report on Assignment 6 is one that we believe has prospects of becoming Manual material. I would like to have the subcommittee chairman, T. A. Tennyson, engineer of tests and sanitation, St. Louis Southwestern, tell you more about this important subject.

T. A. Tennyson: While there is no simple solution generally applicable to all industrial-type, water-borne waste-disposal problems, since each situation may require individual attention, your committee's report points out the essential considerations common to such problems.

In the first place there is need for an organization similar to that which handles water-treatment problems. This should be headed up by an individual who is familiar with laboratory procedures and has adequate training and supervisory ability to do the job. He should have adequate authority to carry out the work, the magnitude of which will somewhat determine the equipment and staff needed.

In the approach to a water-pollution problem there must be complete knowledge of the receiving water, the wastes and the applicable regulations. It may be possible to utilize existing city sewerage systems or industrial waste-disposal facilities or to eliminate or reduce certain wastes at their source.

If design of railroad waste-disposal facilities is indicated, this can be accomplished by contract with outside firms who are in this sort of business or by means of railroad personnel using data published in the literature.

In any event, the proper operation and control of the facilities are essential to success.

Solid wastes present still another problem, the solution of which will depend almost entirely on the local situation.

The report contains references to literature which should be in the hands of all concerned with waste disposal problems.

Your committee presents this report as information now, with the understanding that it, or a revised version, will be recommended for inclusion in the Manual next year.

President Woolford: Thank you, Mr. Tennyson. Your report will be so received.

Assignment 7—Inspection and Maintenance of Diesel Fuel Oil Storage Tanks.

CHAIRMAN TEAL: Our report on Assignment 7 is a presentation of recommended procedures for the inspection and maintenance of diesel fuel oil storage tanks. We believe that it represents good, sound practice and that this information should be made available to the railway people concerned. The report is offered as information at this time, with the idea in mind that it will be reviewed and in its present or in a revised form will be recommended for inclusion in the Manual next year.

Assignment 8—Methods of Controlling Spillage of Fuel Oil at Diesel Fueling and Unloading Stations.

CHAIRMAN TEAL: Our current report on Assignment 8, submitted as information this year, covers automatic fueling devices. General principles and the advantages and disadvantages of automatic shut-off systems are reviewed, and five currently available models are described in words and by pictures. The information assembled to date leads to the conclusion that the automatic fueling devices now available are still in the proving stage. So far as could be determined by questionnaires, none of these has been found fully satisfactory. Among the drawbacks are high costs, and the manufacturer's general disregard of standardization and provisions for interchange of equipment. However, on the other hand, and depending on the number of diesel units to be fueled, the fuel oil savings envisioned by having automatic shut-off valves would amortize the cost of installing the most expensive system in less than three years. In recognition of the need for further improvements and the fact that manufacturers will spend money for such developments only when they have evidence that the railroads are interested, it is suggested that the railroads should encourage further development of automatic fueling devices by purchase of systems, at least on a trial basis.

Assignment 9—Disinfectants, Deodorants, Fumigants and Cleaning Materials, Collaborating with Joint Committee on Railway Sanitation, AAR.

CHAIRMAN TEAL: There is no published report on Assignment 9. A draft prepared by the subcommittee during the past year is to be revised.

Assignment 10—Railroad Aspects of Radioactive Substances, Collaborating with Joint Committee on Railway Sanitation, AAR.

CHAIRMAN TEAL: There is also no published report on Assignment 10 for this year.

Assignment 11—Methods of Heating Fuel Oil to Permit Winter-Time Use of High-Pour-Point "Economy" Grade Fuel Oil.

CHAIRMAN TEAL: Our report on Assignment 11 is a condensation of information collected during the past two years. The report is submitted as information with the recommendation that the subject be discontinued. The variables encountered and the technological advances that are being made in the fuel oil field precludes development of recommended practices that could hold good for any length of time.

Assignment 12—Plastic Pipe and Its Uses on Railroads.

CHAIRMAN TEAL: Our report on Assignment 12 is also presented as information, with the recommendation that the subject be discontinued. The report describes the various types of plastic pipe now available and their possible uses in railroad installations. This is information that is not considered adaptable to the Manual.

Before leaving the platform, I would like to have the subcommittee chairmen, who have worked so faithfully on these assignments, stand and be recognized by the Association.

E. C. Harris, engineer tests, Missouri Pacific, chairman, Subcommittee 1.

J. J. Dwyer, chief chemist, Chesapeake & Ohio, chairman, Subcommittee 2.

J. C. Roberts, fire and sanitary engineer, Union Pacific, chairman, Subcommittee 3.

W. F. Arksey, engineer water service and fuel facilities, Great Northern, chairman, Subcommittee 4.

E. M. Walters, assistant engineer of water service, Northern Pacific, chairman, Subcommittee 5.

T. A. Tennyson, engineer tests and sanitation, St. Louis Southwestern, chairman, Subcommittee 6.

V. C. Barth, chief metallurgist and engineer of tests, Chicago & North Western, chairman, Subcommittee 8.

R. S. Glynn, director, Sanitation Research and Development, AAR, chairman, Subcommittee 9.

R. O. Bardwell, nuclear engineer, Denver & Rio Grande Western, chairman, Subcommittee 10.

C. E. DeGeer, assistant engineer water service and fuel facilities, Great Northern, chairman, Subcommittee 11.

I. C. Brown, water engineer, St. Louis–San Francisco, chairman, Subcommittee 12.

Mr. President, this concludes the report of Committee 13.

President Woolford: Thank you, Mr. Teal. In spite of the passing of the steam locomotive, with its many water service problems, it is evident that there is still a large field of activity for your committee as it has expanded its interests and responsibilities into oil and sanitation services. I congratulate you and your committee on the material and tentative material which it has presented for inclusion in the Manual, in order that the Manual may ultimately include recommended practices with respect to all important aspects of water, oil and sanitation services on the railroads. With a lot of "unfinished business" still before you, including the design and development of a practical and economical coach-watering hydrant which will comply with the regulations of the U. S. Public Health Service, I hope that your committee will hit these problems hard in the year ahead. Thank you again for your report this morning.

Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Cooperative Relations with Universities

[For report see pp. 611–631.]

[President Woolford presiding.]

President Woolford: Our third committee to report this morning is Committee 24—Cooperative Relations with Universities, the chairman of which is W. H. Huffman, assistant chief engineer—construction, Chicago & North Western Railway. Mr. Huffman, will you and the other members of your committee please come to the speaker's table promptly and present your report. If your various subcommittee chairmen are to present reports, I would appreciate their taking places here at the main speaker's table, as close as possible to the podium. Mr. Huffman, you may proceed.

While these people are coming to the speaker's table, I want to remind you again that we will appreciate any comments that you care to make from the floor.

CHAIRMAN W. H. HUFFMAN: Mr. President, members and guests:

The report of Committee 24 will consist of short, brief reports on our assignments, a review by one of our members who is the AAR representative in the American Society for Engineering Education, and a special feature by another of our members, the subject being as shown in your program.

Before proceeding, Committee 24 wishes to express its sorrow at the passing of one valued member during the year—Walter Clifford Sadler, professor emeritus of Civil Engineering, University of Michigan, who passed away at Pacific Palisades, Calif., on October 14, 1959. He joined the AREA in 1926, becoming a member of Committee 14 in 1930, and of Committee 24 in 1940, remaining on both these committees until his death.

Professor Sadler gave generously of his time to committee work and enjoyed an excellent reputation for his broad experience and judgment. Members of Committee 24 sincerely regret his untimely passing and will miss their friendly association with him.

The committee reports for this year can be found in Bulletin 555, commencing on page 611.

Assignment 2—Stimulate Among College and University Students a Greater Interest in the Science of Transportation and Its Importance in the National Economic Structure by (a) Cooperating with and Contributing to the Activities of Student Organizations in Colleges and Universities.

CHAIRMAN HUFFMAN: In carrying out our Assignment 2, a considerable number of our committee members as well as many other railway engineering officers contributed their time and effort addressing student groups in all parts of the country. These presentations covered a multitude of railroad engineering subjects, and I am sure many students gained from them a better understanding of and respect for our industry. I feel very strongly that this personal contact is one of the better ways to attract students and hope more can be accomplished along this line in the future. Professor B. B. Lewis of Purdue University, as subcommittee chairman, has done an excellent job in assembling the information contained in his report. Professor Lewis, will you please stand and be recognized.

Assignment 3—The Cooperative System of Education, Including Summer Employment in Railway Service.

CHAIRMAN HUFFMAN: For the second consecutive year, this committee has canvassed Class I Railroads in the United States and Canada regarding opportunities for summer employment. The information received was submitted to the deans of 125 colleges, and I'm sure those roads which indicated that summer positions were open had many more applications than jobs to be filled. This is another means of providing the necessary spark to encourage students in a railroad career. This subcommittee is headed by Professor W. A. Oliver, University of Illinois, who has done a most commendable job with this assignment. Professor Oliver.

Assignment 5—Consider the Advisability of Establishing Student Membership in the AREA.

CHAIRMAN HUFFMAN: It was the consensus of the entire committee that a student membership classification would result in a definite advantage to the railroads, as well as an advantage to the students concerned. We recommend to the Board of Direction that necessary action be commenced to amend the constitution accordingly. John Stang, division engineer, New York Central, is chairman of this subcommittee. Mr. Stang.

Assignment 6—Procedures for Orienting and Developing Newly Employed Engineering Personnel.

Chairman Huffman: To date, an analytical study has been made on present training programs within the railway industry. As this study continues, we hope to be able to present a recommended program that will benefit all railroads, regardless of their size. What we should want and expect from a good training program was very ably summarized by your president, Mr. Frank Woolford, who said, and I quote:

"If we are to gather and keep young college engineers, we must realize what each one is trying to achieve in society. I believe these are as follows:

a. He wants to do professional work.

b. He wants an opportunity for promotion as a professional engineer.

c. He wants financial incentive as a reward for his increasing contributions to his company.

d. His job must be supervised from a professional viewpoint.

e. He wants, and must have, professional recognition within the enterprise and the community as a whole.

"I feel if we (management) keep these things in mind in orienting and developing newly-employed engineering personnel, we cannot help but succeed in making our engineering family a happy and successful one—a duty with which we are certainly charged."

I certainly concur in Mr. Woolford's remarks. This assignment is being very ably handled by R. E. Loomis, supervisor personnel, Elgin, Joliet & Eastern. Mr. Loomis, will you please stand and be recognized.

Assignment 7—Stimulate an Interest by College and University Staff Members in Current Railroad Problems and Practices, Including AREA Membership.

Chairman Huffman: This assignment was divided into two parts. Part 1 involved the mailing of a questionnaire to the deans of 125 accredited engineering schools to determine the attitudes of college faculties toward the railroad industry, railroad engineering, and the AREA. Some of the replies received were classics, and I would suggest you read this report for all of the details. Part 2 covered the compilation of a list of railroad problems suitable for post-graduate work. The original list is rather extensive. However, we realize it cannot remain static but must be revised frequently. These suggested topics have now been sent to over 200 schools as an aid to master and doctoral candidates who are looking for research problems. Professor W. W. Hay, professor of railway civil engineering, University of Illinois, as chairman, has done an exceptional job on this assignment. Will he please stand and be recognized.

Now, I would like to have one of our members, who is the AAR representative in the American Society of Engineering Education, come forward and tell us briefly on his activities. He is J. F. Davison, assistant to system chief engineer, Canadian National Railways.

Special Report on Relations with the American Society for Engineering Education

By J. F. Davison

Assistant to System Chief Engineer, Canadian National Railways

The American Society for Engineering Education is composed of some 420 institutional and 9200 individual members. In 1954, the Association of American Railroads

became an associate institutional member of the ASEE, and this interest was vested in AREA Committee 24, which is quite appropriate as the function of this committee is "Cooperative Relations with Universities." Until his retirement from the Pennsylvania Railroad in late 1957, C. G. Grove was designated as the AAR member of ASEE and ably represented the railway industry as a member of the Relations With Industry Division. I consider myself extremely fortunate to have been selected to inherit Mr. Grove's duties in this field.

The objectives of the RWI Division as stated in its Constitution and By-Laws closely parallel the objectives of AREA Committee 24. This is indicated by selected paragraphs of Article II of the RWI constitution as follows:

(a) To maintain friendly and fruitful relationships between industry, including government agencies and engineering education.

(b) To increase college—industry understanding of mutual problems and objectives.

(c) To cooperate with educational institutions, professional societies, and other segments of the engineering profession in such matters as:

(1) Counseling, selecting and recruiting potential engineering students.

(3) Professionally sound standards for recruiting engineering graduates.

(d) To keep engineering educators informed of industry's diverse and changing requirements, and the adequacy of the education of their graduates in industry.

(g) To evaluate trends of influence on engineering education and their implications.

The objectives of the RWI Division are furthered through the activities of 16 local sections composed of representatives from both industry and universities within each section. In addition to providing the means whereby problems of sectional interest may be discussed, the local organizations further the national interests of the ASEE through college—industry conferences held once each year on the campus of some university. While it is natural that most of the 300 or more ASEE members attending these conferences come from local areas, a substantial proportion represent nation-wide interests, and this is particularly true of RWI Division members. Each college—industry conference develops a specific theme and chooses eminent authorities to speak or lead discussions on subjects related to the theme. Recent college—industry conferences have developed the following themes:

1960 Washington University, St. Louis, Mo.
THEME: "The Young Professional Engineer—Our Mutual Responsibility"

1959 University of Houston, Houston, Tex.
THEME: "Industry Speaks its Mind on Engineering Education"

1958 University of Michigan, Ann Arbor, Mich.
THEME: "New Concepts in Education and Development of Technical Manpower"

From industry's point of view, however, the greatest opportunity for contact with ASEE members is at the annual meeting held in June each year, at a different university. At these meetings, papers are presented on many subjects of interest to the railroad industry, in both technical and non-technical fields. Many of these sessions would rank in value with AMA seminars and workshops. Meetings of the RWI Division are held in conjunction with both the ASEE annual meeting and the college—industry conference.

Your representative has attended the annual meetings held in 1958 at the University of California and in 1959, jointly at Carnegie Institute of Technology and University of Pittsburgh, as well as the college—industry Conferences which were not too distant.

While this report may appear to contain unnecessary detail, its inclusion is intended to indicate the interest industry has taken in subjects of mutual concern in the field of engineering education. As the representative of AREA Committee 24, I can assure you that attendance at these meetings is an experience I would not like to miss, but I feel strongly that the railroad industry is missing an opportunity in having only limited representation in the ASEE. The constitution of the RWI Division states in Article III that, "All individual members of the ASEE are welcome to participate in the activities of the Division", and I am confident that the interests of the railroad industry would be furthered if individual roads would sponsor their own representatives to the RWI Division. Not only would the industry benefit by the expression of greater interest through increased representation, but the benefits to the individuals attending the ASEE annual meetings, for example, are well worth the cost involved due to the educational value of the technical and non-technical sessions available to them.

Recently, a few railroads have recognized the benefits to be gained through membership in the ASEE, and, in conclusion, may I express the hope that many more will follow their example. [Applause]

Chairman Huffman: Thank you very much, Mr. Davison. I'm sure your assignment with this Association is both interesting and educational.

Now, I would like to present another of our members, V. J. Roggeveen, associate professor of civil engineering and transportation, Stanford University. He will address us on the career development of engineers on seven railroads. Professor Roggeveen.

The Career Development of Graduate Engineers in Seven Railroad Engineering Departments

By Vincent J. Roggeveen

Associate Professor of Civil Engineering and Transportation, Stanford University

Introduction

This paper discusses several points related to the career development of college graduate engineers in railroad engineering departments. It is based on a small portion of a three-year research project, the primary focus of which has been on comparing the organizational structure of seven railroad engineering departments. These companies, all of which were very cooperative, remain anonymous here. The study topic was suggested to the writer by the president of one of the larger railroads. Financial support was provided by the Ford Foundation. The ideas are, of course, entirely those of the author.

The data supporting the findings were collected by interview, examination of organization charts and study of personnel records. Over 200 people were interviewed and 22 cities were visited, many of them several times. The writer first prepared a paper in which he reported his research findings in detail, but this proved to be too long for the space available. Therefore, separate points are presented herein without either the supporting data or a completely integrated discussion of all aspects of the topic; it must be emphasized that in all cases supporting evidence is available.

No attempt has been made to generalize for the industry; it is left to each reader to determine whether any part of the analysis has any pertinence to his own organization.

General Findings

In all seven companies the engineering organizations, at headquarters, decentralized offices and on line, are responsible for much the same physical plant—the track, structures, signals and communications. The scope and variety of these facilities depend naturally on the size and incremental technical complexity of each railroad; for example, signalling and communication facilities are considerably more extensive in some companies than in others. The engineering functions being carried out are also very similar; in every case they include planning, design, construction, maintenance and administration.

However, there appear to be considerable variations in how the engineering departments are organized to carry out these functions on these facilities. Similarly, and of primary concern here, there are wide differences in management policies and practices relating to the educational background, training and career development of the graduate engineers employed in these departments. This latter point, particularly as it concerns civil engineers, will be the subject of the remainder of this paper.

Functions Being Performed by Graduate Engineers

The evidence shows that numerous college graduate engineers are employed in railway engineering departments. Some companies have many, others a few, while the author observed a couple of engineering departments with almost no graduate engineers on the staff. A large majority have had civil engineering undergraduate training; a few men hold Master's degrees and the writer discovered one man with a Doctorate, working as a structural designer.

Graduate civil engineers and their equivalents with practical training are performing several quite varied functions:

1. Engineering administration—The administrative and management functions being carried out by engineering officials in the general, regional, district and division offices.
2. Location and planning—Planning and design of tracks, yards, building locations and similar work.
3. Structural design—Design of structural work for a wide variety of projects involving maintenance, alterations and new construction.
4. Construction—Project management and field supervision.
5. Maintenance of way supervision—The work of track supervisors and bridge and building supervisors out on line.
6. Office engineering—General surveying, minor design, A.F.E. preparation, report compilation, crossing permit preparation and similar tasks.
7. Technical specialties—Architectural design, work on technical details about rails, ties, maintenance of way methods, and so forth.
8. Valuation engineering—A specialized function related to accounting but requiring extensive engineering knowledge.
9. Technical research and development—Development of new technical ideas related to fixed plant facilities, being done in four of the seven companies visited, but a part of the engineering organization in only one.
10. Industrial engineering—Concerned with methods, cost control, processes, scheduling, production planning, etc.

Electrical engineers mostly carry out similar functions insofar as they apply to signals, communications and electric traction fixed facilities and to a minor extent to electrical distribution systems and electrical machinery in yards, buildings, movable

bridges, loading and unloading installations, etc. Mechanical engineers are employed in some engineering departments to work on the mechanical equipment in similar installations.

Several Findings About Career Development

There are a number of current practices, and differences between them, that will be commented on.

Several railroads have formal training programs; these are intended both to help the new engineer in his transition from school to job and to teach him many of the specific details of railroad engineering work. They seem to present some problems in every company that has them: (1) The emotional need of many individuals is to be assigned to a productive job rather than to continue in a lengthy learn-by-observation program. (2) The need of management to fill specific job openings necessitates pulling men out of training programs before they complete them. (3) In two companies groups had completed training programs in the past without specific job openings then being available to which the individuals could be assigned; at this point many of the men had resigned with accompanying unhappiness both for the individuals and the managements involved.

Some managements seem to be groping toward ways of placing a man in productive work sooner, while at the same time still helping both the individual and the company to find the function in which he would fit best by offering him some wider opportunities for continued varied training than might be possible if he were committed early to only one position and the logical promotions from it.

There are major variations in practices as to early job assignments. In some railroads it is felt to be almost indispenable that practically all young engineers should gain first-hand track experience in such positions as track inspectors, assistant track supervisors or track supervisors. Others require such experience only for those being developed to fill line engineering positions. Several managements desire to assign young engineers to these positions, but are inhibited from doing so by seniority or union contract considerations. One large railroad employing many civil engineers feels that this is too low a level at which to use a college graduate. The duration of such track experience varies from none at all in some companies to about 18 months to 2 or 3 years in some others, to as much as 5 to 8 or even 10 years in one organization.

Practices as to other starting positions are equally varied. One large railroad for many years has started graduate engineers as rodmen or chainmen in its division engineering offices, using them for surveying duties, to do simple drafting, make blueprints, preparing routine A.F.E.'s, etc. A majority of the companies deem these to be subprofessional assignments best given to men with practical backgrounds or to recent high school graduates. One large railroad starts its young engineers, after they have completed their training program, as the office engineer on a division. Two railroads start almost all graduate engineers in structural designing work. One company has practically no graduate engineers with field experience.

The position of office engineer is considered to require a college education in some companies, not to require it in some, and to be particularly suited to non-college graduates in some others.

Careers are almost entirely devoted to the engineering function in some railroads. In others, individuals spend anywhere from 5 to 20 years in engineering and are then given an opportunity to gain transportation experience. One company is making an effort to provide highly diversified operating and staff experience as soon as possible.

No engineers were found who had transferred from or into the sales or traffic departments, contrary to the practice in many outside industries where engineers often find this to be a functional area very suited to their talents.

The patterns of career development are clearly predictable in some companies, so much so that a man can tell fairly well how he "stands" with his superiors by whether each promotion occurs at about the time it should. In others promotions are unpredictable and seem at times to result from management having no long-range personnel plans or policies at all.

In some companies promotions are frequent, in others occasional, and in some occur only at intervals of many years.

In some railroads an individual may become a division engineer at 40, in others at 35, and in still others at 30. In some an engineer may practically never become a division superintendent, in others they reach this position in their 30's, and in one large railroad the author met two men holding this position before their 30th birthdays. Ages at which individuals become chief engineers seem to range from about 35 to 55. In some of the engineering organizations ages of individuals are graduated to roughly correlate with the various levels of positions they hold. In others all ages are to be found at all levels of responsibility. Some companies have practically no men in certain age groups, due to cyclical hiring or layoff practices in the past, and one has far too many older men with insufficient younger ones following them to take their places.

Some managements believe strongly that careers and promotions should be entirely within their one company; others that they should be within the railroad industry; while several others are of the opinion that railroads should also hire some experienced engineers from outside industry, particularly in such technical specialities as architecture, structural design and communications engineering.

In most of the railroads an engineer to be considered successful has to pursue a career in management, with primary emphasis on experience out on line, both in engineering and transportation. A man who is more interested in a technical specialty, for example structural design, receives less frequent promotions or salary increases and after 20 years or more typically earns substantially less than his colleagues concerned with administration. A few companies have an entirely opposite point of view, and make it possible and desirable to pursue a professionally and financially rewarding career specializing in a technical function.

Transfer practices are widely varied and are frequently criticized by men who are otherwise entirely satisfied about their companies. There seems to be a fairly frequent feeling that living and working conditions have changed in recent years with the result that transfers are more difficult for an individual now than they were when present higher officials were going through the same experience some years ago. A common complaint is that adequate homes can no longer be rented in many communities, particularly not on short notice, but have to be bought and subsequently resold with the accompanying payment of a broker's commission and a serious timing problem when a house in a new community must be acquired before a previous one has been disposed of. Younger marriage ages and larger families undoubtedly contribute to making the transfer problem more acute. Some individuals express the opinion that transfers often seem to result in little visible advantage for them, that they are often improvisations rather than part of an overall plan, and above all that notices of transfers are too short. These notices range from practically no advance warning at all, to the more typical 15 days, to one company that tries to forewarn a man a month ahead. One engineering official

explained that it is necessary to make this sort of decision quickly and that it is impossible to give more warning. When asked, "Suppose your president would tell you that you have to give a month's notice except in case of emergency, what would you do?" He replied, "I guess I'd manage."

In those companies that have research and development organizations career practices for individuals in these groups are sometimes completely opposite to career practices in the engineering departments. This fact is particularly striking when engineering officials imply that their managements wouldn't find any alternative practices acceptable. For example, in six of the seven railroads, with the exception of AREA activities, there is not much active participation by the engineers in the activities of technical societies of national stature, such as ASCE, ACI or ASTM, for example, through publication of papers. By contrast, such outside activities appeared to be quite common for research and development personnel. Again, engineers are only occasionally sent to or given formal refresher courses to enable them to learn about new technical developments, while this, too, is fairly common for the research and development people. Except in the one company where research is carried out within the engineering department, many research and development staff have been brought in from outside industry and most of them have no railroad engineering or operating experience. Such differences frequently seemed to contribute to a feeling of distance between the two groups. On the other hand, one company makes it a practice to have a constant flow of people in and out of its separate research and development department from and to other departments of the company; this helps to integrate the work and contribute to mutual understanding.

In all of the companies most of the engineers are kept more than busy with their day-to-day duties, leaving little opportunity for reflection as to how railroad engineering techniques might be improved or how work now being done might be changed or even eliminated.

Starting salaries seem to be reasonably competitive with those generally offered to graduating engineers by outside industry; they obviously have to be or few individuals would be hired. Much less value is placed on a Master's degree than in most other industries, some of which insist on this extra training. Progression in salary varies widely; in many companies engineers with many years of experience do well if they earn double the starting scale unless they move into broader operating responsibilities. ICC statistics on compensation of railroad officers showed that salaries of chief engineers vary widely, many are as low as $10,000 to $13,000, quite a few are above $30,000. In terms of salary practices railroads seem very similar to many highway departments, even though not bound by civil service regulations. Many educators suspect that low remuneration is one of the important contributing reasons why enrollments in civil engineering continue to decline in a trend opposite to that in some of the other technical fields where the salary scales for men doing professional work are a good deal higher.

Summary

While these far from exhaust the author's findings as to career development, they are as much as space permits enumerating here. It is evident that engineering officials of railroad companies are vitally concerned with the careers of their graduate engineer employees and are making every effort to develop them as best they know how. It is also clearly evident that there are a number of very different concepts as to what policies and practices in this regard are most desirable or most practical. This takes on particular significance in view of the fact that the functions being carried out are so similar. As a result, the writer is led to suggest several thoughts and questions, as well as a concluding suggestion.

Discussion

In many railroads an engineer not only starts at the bottom and works up, but also usually starts at the edges and works in. He typically begins in subordinate positions out on line or at headquarters spending his early years forgetting many of the things he learned at college while learning from his colleagues and immediate superiors how things should be done, which is unfortunately all too often how things have been done in the past. As he progresses upwards he attains levels of responsibility at which he can implement new ideas. However, by now his thinking and attitudes are often well conditioned by his employment experience so far. This results in a very different situation than in some of the newer technologies, where men in their 20's and 30's are making many of the most significant professional contributions.

If at age 30 engineers can put rockets around the moon, develop entire new technologies, such as solid state electronics, and if the entire crew of a nuclear submarine cruising under the North Pole are in their 20's and early 30's, would not railway engineers given equal opportunities at this age perhaps also make significant contributions to the technology of railway fixed plant design, construction and maintenance? Would not the opportunities to make such contributions help to attract outstanding young engineers to railroading? Would it not be possible to bring younger men into the general office fairly early in their railroad career, after gaining some initial experience out on line, let them work with engineering management on the development of new methods and ideas, learn what the latest thinking of others is about railway topics; then send them back into the field to implement these new concepts? Would it not be possible to rotate men between engineering and transportation on the one hand and research and development on the other on a much more frequent basis than now, and thus cross-fertilize the work of both groups, rather than keep them from knowing each other too well as at present? Could not such rotation perhaps also be in the form of assigning engineers from individual railroad engineering departments to the staff of the AAR Research Center for a year or two so that with their return to their own company they would bring back with them exposure to both new railroad technology and the methodology of research, to then be applied to specific problems at their own railroads?

Would it not be worthwhile to take more intensive steps to assure the constant updating of the general knowledge of railway engineers? While railway trade publications can help to do this job, they can make only a small beginning at keeping an engineer up to date with the details of the rapid progress of technology today. How many railway engineers, for example, are familiar with modern statistics, computer programming, photogrammetric techniques, or new developments in industrial engineering, to name a few? Here again, those of us in the educational profession cannot help but notice that less is being done by railway management to keep their technical people not only abreast of but ahead of technological techniques and developments compared to what is being done by many outside industries.

Industrial Engineering as an Educational Background

It is instructive to compare the variety of functions being performed by civil engineers employed by railroads with the curricula now being given to civil engineering students in many leading universities.

There is a well defined and rapid trend toward the teaching of more and more engineering science, including advanced mathematics, physics, engineering mechanics, fluid mechanics, electronics and similar subjects and elimination or marked reduction in the more "practical" subjects such as surveying, drafting and survey courses in

transportation engineering, sanitary engineering, engineering economy, etc. These educational programs are directed toward preparing an individual to do a better analytical job in working on the increasingly complex technology of today. This new type of course should be well suited as preparation for railroad employment on structural design, some technical specialties, or research and development. Is it as well suited in terms of specific course content for work on maintenance of way, engineering administration, office engineering or valuation work? Is it as suitable as the alternative of a practical background acquired over a period of time in these specific areas?

On the other hand, another engineering discipline taught in many colleges and universities seems almost entirely absent in those railway engineering departments the writer visited; he did not discover a single individual with a college major in industrial engineering in any of them. Three companies are doing a considerable amount of industrial engineering work, some of it related to fixed plant. In one case this activity is centered within the engineering department, in one case in a separate industrial engineering department, and in the third it forms a part of the research and development organization. In the first, civil engineers had attended short specialized courses of a few weeks duration. In the second, the separate department is headed by an experienced industrial engineer brought in from outside industry, with a staff of 16 engineers, a third with this form of education. In the third company men with various backgrounds are being used.

Is not the primary problem of maintenance of way that of increasing productivity by doing more work more efficiently at less cost? Is not the modern maintenance of way gang essentially functioning as a moving factory, running an outdoor production line in which the product is large-scale replacement of old components by new? Is this not much more related to the entire conception of a contemporary industrial engineering education than to a contemporary civil engineering course?

At Stanford, for example, undergraduate industrial engineering students take such courses as: manufacturing processes, industrial organization and management, motion and time study, production engineering, production control, statistical quality control, industrial accounting, operations research, data processing, machine shop processes, probability theory, statistical methods, business law, industrial relations and engineering economy. At the same time the student also takes the core curriculum program in engineering mechanics, mechanics and properties of materials and fluids, principles of electrical circuits, electrical machinery, electromechanics, thermodynamics and principles of physical metallurgy. The industrial engineering programs at M.I.T., Purdue, Case, Carnegie and many other schools are quite similar.

Railroad engineering pertaining to fixed plant has been undergoing many profound changes in recent years, particularly as applied to maintenance work. Engineering curricula are profoundly changing as well. Would it not be worthwhile for engineering management of railroads to make a reappraisal of what it expects from the graduate engineers it plans to employ?

Are the railroads employing graduate engineers, as officials in all the companies have emphasized repeatedly to the writer, primarily for their ability to think, analyze, solve problems, communicate, manage and work in a technical environment? If so, then would not any undergraduate training be suitable, and not only civil engineering? Are these men also being hired for their specific technical training? Then, while the civil engineer is probably best suited for structural design, or location and planning, would not another type of engineer perhaps be more suited for work on maintenance of way and various aspects of engineering administration? Might this not be the industrial engineering graduate?

The author, a civil engineer by training himself, does not by any means suggest that *only* industrial engineers should be hired, but calls attention to the fact that in many companies *no* industrial engineers are now employed. There is a wide opportunity for a happy medium between these two extremes. With the variety of engineering functions to be performed, would it not be worthwhile to consider employing people with a similar variety of engineering training? In the long run this should be an asset to the civil engineer, for a further raising of the technical sophistication of all railway engineering work should upgrade his functional role as well.

To close this particular topic with an analogy, a mechanical engineer is needed to build an automobile, but certainly not to maintain it or to drive it. Similarly a civil engineer is best suited to design and build a railroad fixed plant but not necessarily to maintain it or to administer it after it has been completed.

Concluding Generalization and Suggestion

The basic generalization the author proposes is as follows: Railway engineering in most companies is very similar in facilities and in functions, but management practices and policies as to career development of engineers doing the work appear to vary very widely, so much so that they were substantially different in each of the seven companies observed. Presumably there are numerous other variations to be found in the other Class I Railroads. This would seem to imply that many managements could be considerably more flexible in their policies and practices, still get their work done, but perhaps realize improvements over their present ways of doing things by adopting ideas already in use in other railroads.

To help achieve this objective the author offers the following suggestion: For 59 years the AREA has provided an organized opportunity for the exchange of technical ideas pertaining to track and structures. The AAR Signal and Electrical Sections do the same for the functions with which they are concerned. The R.S.P.A. is similarly helping the exchange of ideas in certain accounting and sales areas. However, there does not appear to be any organized opportunity other than the railway technical press for similar intensive exchange of thinking and experience about the management of railway engineering departments.

Would not a formal organization or avenue of communication devoted to this specific purpose fill a very real gap? Perhaps a new committee of the AREA devoting its attention to this specific area might be an excellent means of doing so.

The author's detailed research findings point up a number of fruitful areas upon which such a committee could profitably work. Like almost any research undertaking, this one has developed several other research topics that would each justify further intensive study. The industry trade publications frequently mention others. Certainly one topic that would be timely and pertinent would be that of the use and development of the engineer in the engineering department of a railroad.

Postscript

The author would welcome the opportunity to discuss with the officials of any railway company, by mail or in person, specific thoughts on any aspect of the management of railway engineering. [Applause]

Chairman Huffman: Thank you very much, Professor Roggeveen. That was a very enlightening dissertation on what many of us know, and I am sure that we will get a lot of very good information by reading your address as it will appear in the Proceedings.

As this concludes my term as chairman of Committee 24, I would like at this time to express my deep thanks to the subcommittee chairman and all the other members for their excellent help and cooperation during the past three years. I would also like to thank Neal Howard and his staff for their many contributions to the success of the work of this committee.

As my last official act, I take great pleasure in presenting to you my successor as chairman, W. W. Hay, professor of railway civil engineering at the University of Illinois. Professor Hay, will you please stand. Professor Hay will make an outstanding chairman of this committee. His attention to, and interest in, our work has been well demonstrated by his activities as vice chairman during the past 3 years. Not only that, but he was very active prior to this last three-year period.

Our new vice chairman, H. E. Kirby, cost engineer—system, of the Chesapeake & Ohio, was unable to attend this convention.

Mr. President, this concludes our report.

President Woolford: Thank you, Mr. Huffman, and members of your committee. Your committee provides this Association and the railroads a tie-in with the colleges and universities, which is highly important, if not essential, to our industry. From several of your reports here this morning, we are satisfied that your committee has made a number of important contributions to this end, but, if I interpret correctly the comments from some professors, as reported under your Assignment 7, it is evident that there is much that must be done by your committee, the AAR, and the individual railroads, if our industry is to hold the proper interest and respect on the campuses of the country—indeed, if we are going to correct a lot of present disinterest and misunderstanding on some of these campuses.

I might stop here a minute and suggest to all of you men that you take time out and read the committee's report on Assignment 7. I, along with the Board, have gone over this quite thoroughly several times, and I think the committee is to be highly complimented for the investigation they made and the conclusions that they arrived at in this study.

Mr. Huffman, under your able leadership, your committee has done much effective work during the past three years and, while we hesitate to see you give up this leadership, we have the utmost confidence in your successor, Professor Hay, and in your new vice chairman, Mr. Kirby, both of whom have been diligent workers in this Association. Mr. Hay, being a college professor, will guide our actions in that direction. I personally know Professor Hay quite well. He has been on our Board of Direction for a considerable time. I, like Mr. Huffman, think that this committee will continue to be in very capable hands.

And in connection with your new vice chairman, Mr. Kirby, I might add that I think the committee has done an excellent job in choosing Mr. Kirby. He is a very active and working member of our Association.

And our thanks to you, Professor Roggeveen, for your incisive study and analysis of the career development of engineers on some of our railroads. We on the railroads in the West were highly pleased with your move from MIT, that little school back there in the East, to one of the foremost schools in the country, Stanford University, in our great State of California. We think you will be a very good addition to our school and we certainly welcome you to the West Coast. When you get settled out there, Mr. Roggeveen, I would appreciate knowing you better. I certainly enjoyed your talk this morning. But I think some of the chief engineers would agree with me that that picture has another side. I would like to talk over that other side with you.

Again, Mr. Huffman, thank you for the report of your committee this morning.

We are running a little behind time, gentlemen, but if you have anything from the floor you would like to say concerning this report, we will take a few minutes to hear it. Otherwise, Mr. Huffman, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Wood Bridges and Trestles

[For report see pp. 585–609.]

[President Woolford presiding.]

President Woolford: The remainder of our convention session this morning will be devoted to structures and structural materials, as we hear successively the reports of our structural committees. The first of these committees to report is Committee 7—Wood Bridges and Trestles, the chairman of which is F. E. Schneider, assistant engineer, Atchison, Topeka & Santa Fe Railway, Chicago. If Mr. Schneider and the members of his committee will come to the platform, I shall be glad to turn the microphone over to him.

While the committee is coming to the platform, I would like to remind you again that the privilege of the floor is extended to everyone here. I hope you will not hesitate to avail yourselves of this privilege to the extent that you may have questions to ask or pertinent comments to make. Certainly, many questions exist among you in our audience concerning structures. Please don't hesitate to put Mr. Schneider on the spot and ask him questions, which I know he and the members of his committee will be able to answer. Mr. Schneider, I turn the microphone over to you.

Chairman F. E. Schneider: Mr. President, members and guests of the Association:

The report of Committee 7 will consist of brief reports by subcommittee chairmen covering work accomplished during the past year. These reports can be found in Bulletin 555, commencing on page 585.

Following the presentation of the reports, I will introduce one of our collaborating members who will present the special feature. The committee invites your comments and questions at the conclusion of each presentation.

Before proceeding with the presentation of our reports, Committee 7 wishes to express its sorrow in the death of one of its past chairmen and a Member Emeritus—Col. H. Austill, retired chief engineer of the Terminal Railroad Association of St. Louis. Col. Austill passed away at his home in Mobile, Ala., on October 20, 1959. He also had been a member of Committee 14—Yards and Terminals; Committee 4—Rail; Committee 26—Standardization; and Committee 28—Clearances. He leaves behind many friends and associates who feel deeply the loss in his passing.

Assignment 1—Revision of Manual.

Chairman Schneider: Our report on Assignment 1 will be presented by Subcommittee Chairman D. V. Sartore, assistant engineer of buildings, Burlington.

D. V. Sartore: Mr. President, members and guests: In accordance with the secretary's request that all Manual material be reviewed prior to reprinting the Manual in 1962, your committee has reviewed approximately one-third of Chapter 7 this year with the results shown on pages 587, 588 and 589 of Bulletin 555.

In most instances, it is recommended that the documents be reapproved without change. In others, where the recommendation is for reapproval with revision, the revisions are editorial in nature.

There are three additional documents in which the revisions are recommended for other reasons: In the document on Definitions of Terms Used in Describing Standard Grades for Lumber, your committee recommends that many definitions be deleted, and that other definitions be combined or revised as noted in Bulletin 555.

Your committee also recommends that the Specifications for Wood Piles be reapproved with revisions to bring our specifications into agreement with recent revisions in the ASTM specification for wood piles.

It is recommended that the Specifications and Design of Fastenings for Timber Trestles be reapproved with revisions necessitated by the revision of recommended plans which were accepted last year.

Mr. President, I move that the recommended action for the various documents shown on pages 587, 588 and 589 of Bulletin 555 be adopted and published in the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 2—Grading Rules and Classification of Lumber for Railway Uses; Specifications for Structural Timber, Collaborating with Other Organizations Interested.

Chairman Schneider: Last year we submitted a report on Assignment 2 as information, with the recommendation that the material be presented for adoption in the Manual this year. However, since it contains references to the National Hardware Lumber Association's specification which is at present out of print, this table will have to be held until proper references to hardwood specifications can be made.

Assignment 4—Methods of Fireproofing Wood Bridges and Trestles, Including Fire-Retardant Paints, Collaborating with Committees 6 and 17, and with the Fire-Protection and Insurance Section, AAR.

Chairman Schneider: The report on Assignment 4 will be presented by Subcommittee Chairman B. E. Daniels, division engineer, Milwaukee Road.

B. E. Daniels: Mr. Chairman, members and guests: For a number of years the study has been concentrated on fire-retardant coatings and paints applied to creosoted wood with the goal of developing a specification for such coatings. A wealth of data has been accumulated in this period of time and is offered as information in Bulletin 555, pages 590 to 600, incl. The committee's work in the future will include continued research, and revision of these data, together with additions which the committee may feel necessary so that a final specification can be recommended for Manual material.

The committee also has made progress in the study of the effect of additives or fire-inhibiting substances in the treatment of timber. A report on this progress is included as information in Bulletin 552, pages 209 to 241, incl. This phase in the development of fire-retardants will be carried out primarily by the AAR research staff, along with their work on the coating specification.

This constitutes the committee's work on Assignment 4 to date and an outline of our future efforts.

Chairman Schneider: May I add that Subcommittee 4 has compiled a questionnaire to be submitted to chief engineers, bridge engineers, etc., asking for their assistance in giving us any data they might have on fire retardants, and their experiences and problems with fire retardants; also, we want them to tell us what they want and what they need. We hope through replies to this questionnaire that we can augment our own information and data. We request that those chief engineers and others who receive the questionnaires answer them for us and help us out on this subject.

Assignment 5—Design of Structural Glued Laminated Wood Bridges and Trestles.

CHAIRMAN SCHNEIDER: The report on Assignment 5 will be presented by Subcommittee Chairman J. A. Gustafson, draftsman, Bridge Department, Northern Pacific.

J. A. GUSTAFSON: Mr. President, gentlemen: Your committee submits as information the report on the "Ultimate Static Strength of a 52-Ft Glued Laminated Timber Girder" shown in Bulletin 555. The report covers the test of a girder 9 in by 36 in by 52 ft containing 22 laminations of Coast-type Douglas fir.

Tests are currently being carried out on glued-laminated stringers 7 in by 16¼ in by 13 ft 10 in to determine the shear strength and the flexural strength under static loads as well as repeated loads. The results of these tests should be helpful in the preparation of specifications for the design of glued laminated members for railway bridges and increase our knowledge of the stresses which accrue in timber under loads.

Assignment 7—Repeated Loading of Timber Structures.

CHAIRMAN SCHNEIDER: Our next report is on Assignment 7 and will be presented by Subcommittee Chairman Clarence Lund, assistant to chief engineer, Milwaukee Road.

C. V. LUND: The information contained in the report on repeated-load tests of bolted timber joints, appearing in Bulletin 551, should be of considerable value to everyone concerned with the design or maintenance of timber trestles. It provides comparative data on the strength of joints with relation to size of bolts, and is the only data available from research that is strictly applicable to our problem.

During the current year it is expected the AAR Research Center will prepare progress reports on two studies dealing with repeated loading of stringers: (1) the results of tests made on 50-year-old treated stringers recovered from trestles located on the Santa Fe near La Junta, Colo., and (2) the results of exploratory tests made at the AAR laboratory of stringers in compression perpendicular to the grain, simulating end bearing conditions, with annular growth rings oriented in three different positions.

It is also expected that the investigation started at the Forest Products Laboratory in 1953 on one-quarter scale stringers will be completed soon and a report written on this extensive series of tests.

A program of tests on full-size solid sawn and glued laminated stringers is planned, which will be correlated to the one-quarter scale tests, and it is hoped that this program might be started during the coming year on a cooperative basis, with the lumber industry and other interests participating. This is a project to which the committee has looked forward for many years.

CHAIRMAN SCHNEIDER: Our special feature will now be presented by L. C. Collister, manager of the Tie and Timber Treating Department of the Santa Fe Railway. Many types of fireproof coatings and additives have been tested on full-scale replicas on the Santa Fe under Mr. Collister's direction. Committee 7 feels very fortunate in being able to have him give us an illustrated talk on fire-retardant treatments on the Santa Fe. Mr. Collister.

Fire Retardant Treatments on the Santa Fe

By L. C. Collister

Manager, Tie and Timber Treating Department, Atchison, Topeka & Santa Fe Railway

Mr. Chairman, members of the AREA, and guests:

It's a real privilege to bring you this summary of our efforts to protect our timber trestles from fire. Mr. Buford in his remarks yesterday suggested the possibility of replacing steel girders with laminated wood girders. These treated with fire retardants become even more practicable. We have been indeed fortunate in having so much cooperation from industry in this problem.

The annual fire loss statistics of the Fire Protection and Insurance Section of the AAR indicate under the designation "Bridges, Trestles and Culverts" the following for the 5-year period, 1954 to 1958:

Year	*Number of Fires*	*Losses*
1954	207	$ 729,518
1955	222	1,116,691
1956	196	930,235
1957	135	267,666
1958	179	576,256
	939	$3,620,366
Average per fire	$3,855.55	

These figures are low, but please remember they represent only the actual loss of bridges from fire, and do not include the costs due to loss of time, delays and rerouting of traffic that may result if a main line is blocked because of the loss of a timber trestle from fire.

In this same period, the Santa Fe had 7 fires with a total property damage of $28,225, averaging $4,032.14 per fire.

Because we have approximately 128 lineal miles of timber trestles, we have been working on this problem of fire intermittently for many years, and actively starting in 1952.

To us on the Santa Fe, studies have shown that the timber trestle is our most economic bridge. Our division bridge forces are trained in this type of construction. Also, because of our experience in preframming and treating our timbers, and our high timber grading requirements, we are getting a life expectancy for ballast-deck trestles approaching 60 years, and for open deck, 55 years.

There are two problems involved in a program of fire protection, namely:

1. Protection of bridges now in track
2. Protection of new construction

For the first, the bridges now in track, the most promising method is a surface treatment with a grease-like material that has phosphorus present in the form of triaryl phosphate. This material penetrates into the wood after a short time (2 to 6 weeks) to give seemingly adequate protection. Retentions are given in Table 3.

For fire protection of new structures, we are currently using triaryl phosphate in our 50/50 creosote–petroleum mixture treating solution. We believe that a retention of 0.1 lb per cu ft of active phosphorus will give adequate protection.

Figs. 1 through 4 illustrate a typical full-scale test. In the first picture, the tumbleweeds are placed ready for ignition. The Douglas fir timbers were treated to refusal with 0.91 percent phosphorus as triaryl phosphate in a creosote–petroleum mixture.

Fig. 1—Full-scale trestle replica test ready for ignition. Douglas fir timbers treated with 0.91 percent phosphorus as triaryl phosphate in a creosote–petroleum mixture.

Fig. 2—Same as Fig. 1, but showing peak fire 45 sec after ignition. Temperature reached 1650 F or higher.

Fig. 2 shows the peak fire which occurs within about 45 sec from the start of the test. Temperatures at this time average approximately 1700 F. taken at a point immediately under the trestle deck.

Fig. 3 shows the fire 8 min after the start of the test; the characteristically sharp decrease in flaming had occurred although burning persisted in protected locations.

Fig. 4 illustrates the elevation and section of our end panel replica for fire test.

Fig. 5, again illustrating the effect of triaryl phosphate, compares time–temperature curves from test fires on trestles of like design. The dotted line represents a treatment using a 20 percent Arban solution in 50/50 creosote–petroleum mixture. Net gain in piles 15.40 lb per cu ft, or 0.22 lb of phosphorus per cu ft. Net gain in lumber 6.70 lb per cu ft, or 0.0938 lb of phosphorus per cu ft.

The solid line represents a treatment of 13½ percent ET-204 (Arban 70) in a 50/50 creosote–petroleum mixture. Net gain in piles 6.68 lb per cu ft, or 0.063 lb of phosphorus per cu ft. Net gain in lumber 5.28 lb per cu ft, or 0.0499 lb of phosphorus per cu ft.

Fig. 6, also illustrating the effect of triaryl phosphate, compares time–temperature curves obtained from test fires on newly treated trestles of like design. The dotted line represents a treatment of 13½ percent Arban 70 in a 50/50 creosote–petroleum mixture. Net gain of piles 14.44 lb per cu ft, or 0.136 lb of phosphorus per cu ft. Net gain of lumber 10.39 lb per cu ft, or 0.098 lb of phosphorus per cu ft.

The solid line represents a treatment of 13½ percent ET-204 (Arban 70) in a 50/50 creosote–petroleum mixture. Net gain in piles 7.97 lb per cu ft, or 0.075 lb of phosphorus per cu ft. Net gain in lumber 11.24 lb per cu ft, or 0.106 lb of phosphorus per cu ft.

Table 1 illustrates the typical analysis of Seguro oil used in admixtures with creosote.

Table 2 is the typical analysis of creosote used in admixtures with the Seguro oil.

The effectiveness of other compounds has been studied. Laboratory tests indicate that a chloroalkyl phosphate and a bromoalkyl phosphonate show three to five times the effectiveness of the triaryl phosphates. However, the triaryl phosphates performed much better in rigorous field tests than in the lower temperature laboratory evaluations. This fact emphasizes the point of Schuyten, et al., that the fire retarding agent must "be present or produced from its precursor . . ." at burning temperatures.

Two haloalkyl phosphorus compounds were tested favorably in a grease-like surface application in which the material was carried into the wood. These materials have the necessary properties, such as good solubility in oils, low solubility in water, low vapor pressure at ambient temperatures, and relatively low toxicity. However, they have marginal stability at treating temperatures in the presence of a small amount of water, and as yet their costs are high.

Fig. 7 illustrates the effect of treatment with a bromoalkyl phosphonate (Pyroban B) and the chloroalkyl phosphate (Pyroban C).

The Pyroban C was sprayed October 6, 1959, on the replica to an average thickness of 0.07 in. The Pyroban B was also sprayed October 6, 1959, to an average thickness of 1/16 in.

Table 3 illustrates the retentions of these materials from various locations sampled.

Early testing showed less fire hazard on untreated timbers than treated timbers. Studies showed that the higher the retention of preservative oils, the greater the hazard, for as you increase the fuel the fire hazard increases. From this, we believe that an increase in the ratio of fire retardant to oil is necessary as the total oil is increased.

(Text continued on page 1105)

Fig. 3—Same as Fig. 1, but 8 min after ignition. Some local burning still persists in protected pockets. Char is about ¼ in deep.

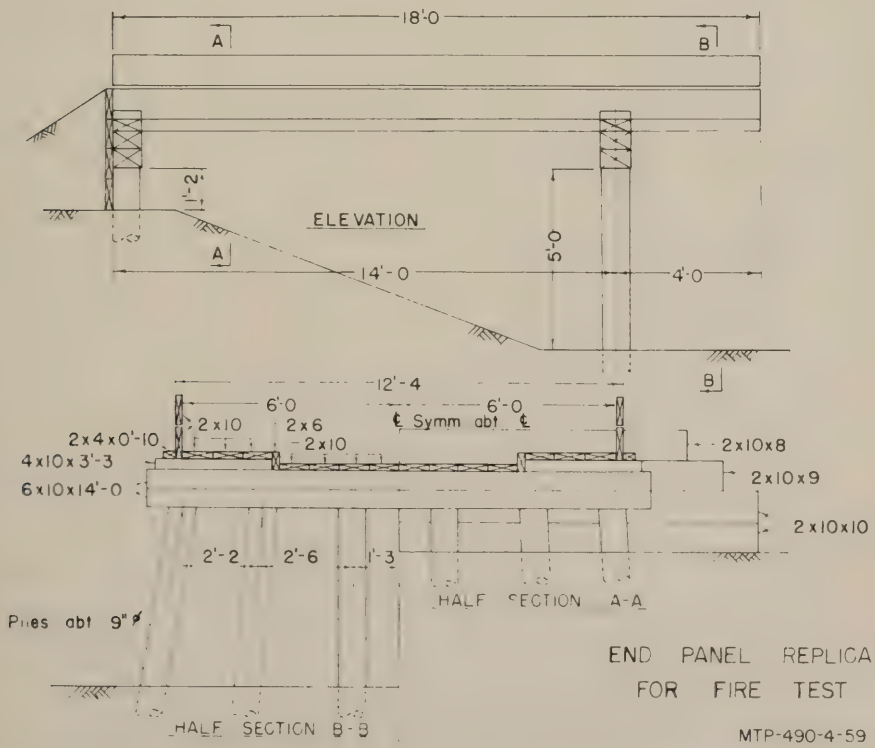


Fig. 4—Plan and elevation of end panel replica for fire test.

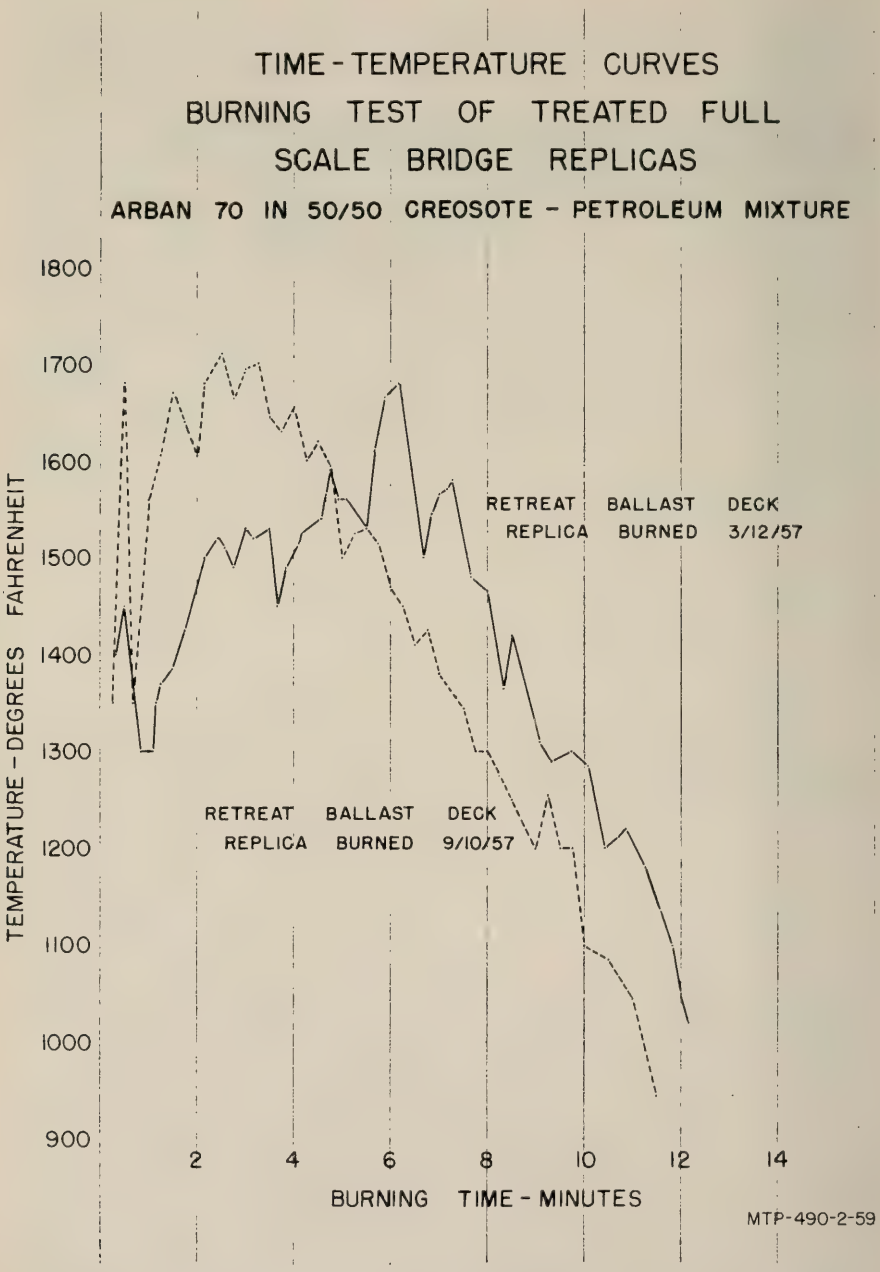


Fig. 5—Time–temperature curves of Douglas fir timbers retreated with creosote–petroleum mixtures containing 1.4 percent and 0.95 percent phosphorus as triaryl phosphate to obtain 0.159 and 0.056 lb of phosphorus per cu ft.

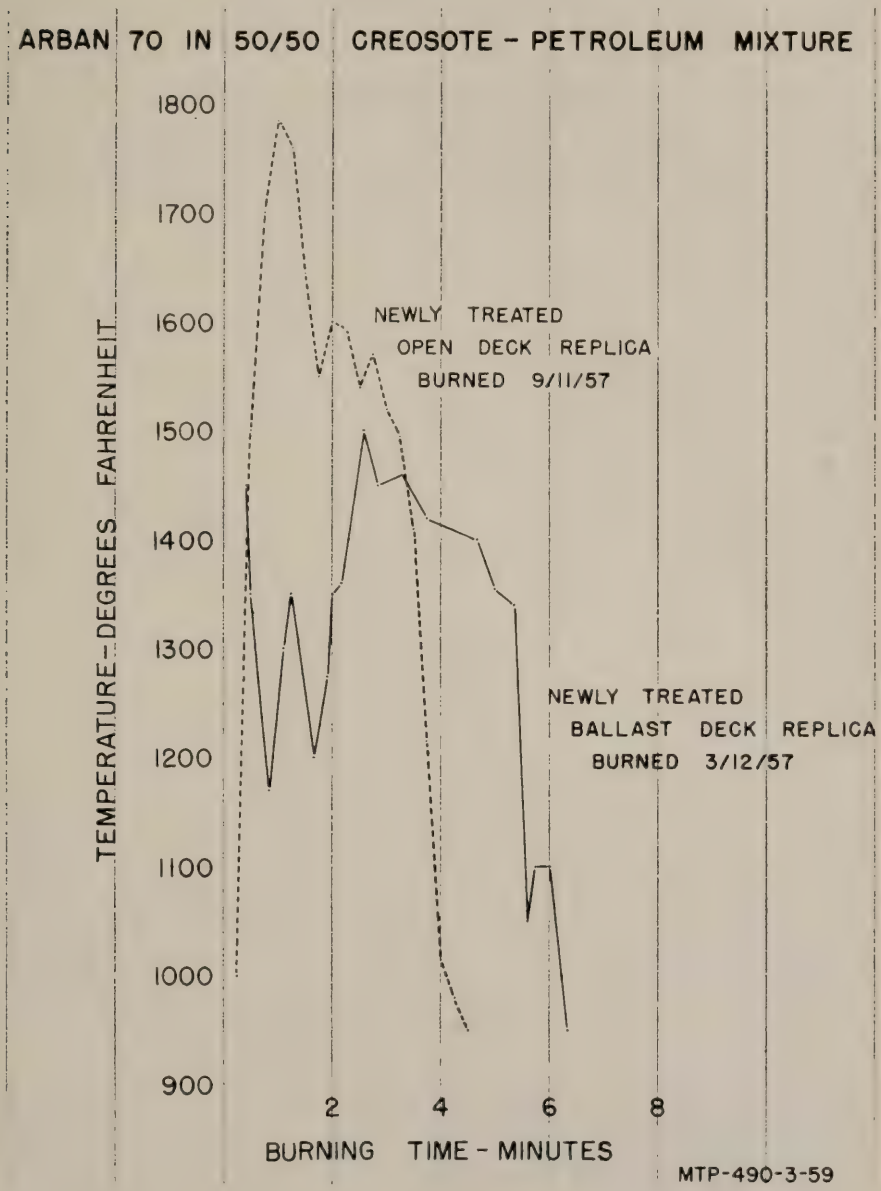


Fig. 6—Time–temperature curves on newly treated Douglas fir timbers with a creosote–petroleum mixture containing 0.95 percent phosphorus as triaryl phosphate to get retentions of 0.117 lb per cu ft as represented by the dotted line, and 0.090 lb per cu ft as represented by the solid line.

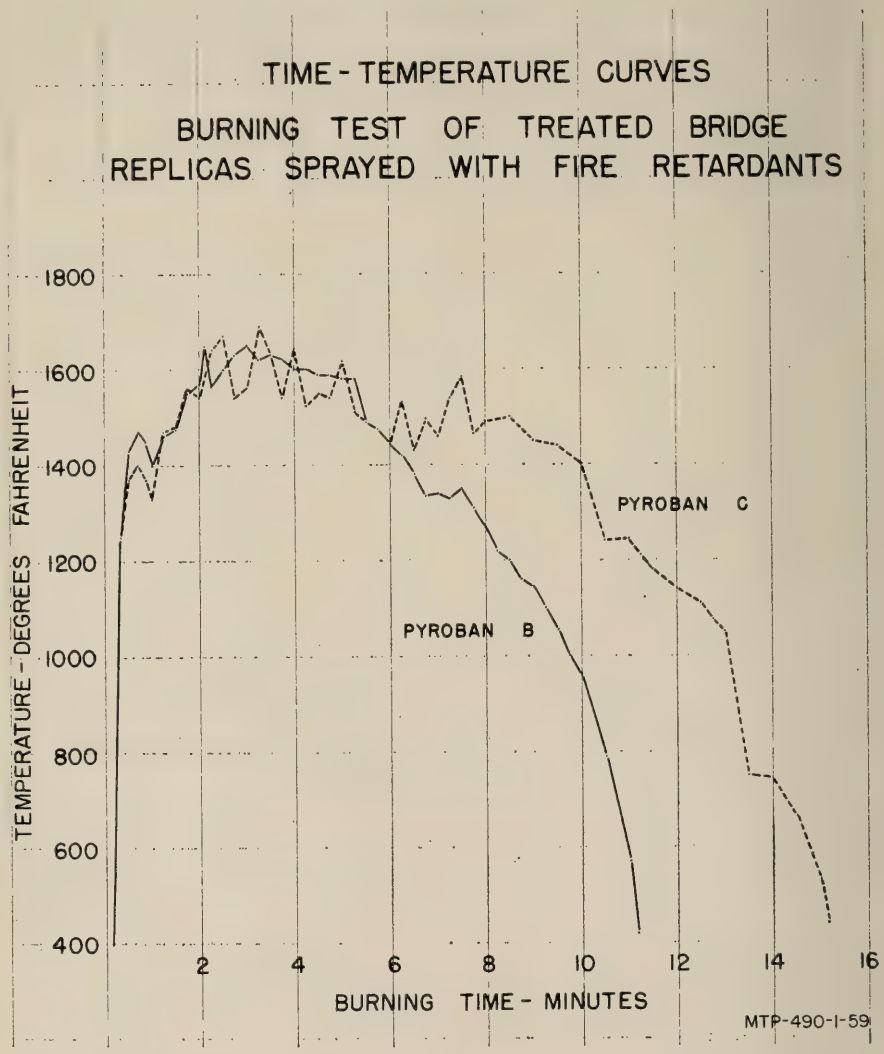


Fig. 7—Time–temperature curves on treated timber replicas sprayed with Pyroban C (a chloroalkyl phosphate, dotted line) to a thickness of 0.07 in. Average retention of 0.166 lb per cu ft phosphorus in outer ¼ in. The solid line represents a coating of 1/16 in of Pyroban B (a bromoalkyl phosphonate). Average retention is 0.268 lb of phosphorus per cu ft in outer ¼ in.

TABLE 1—TYPICAL SPECIFICATION OF SEGURO OIL USED IN TRESTLE REPLICA TESTS

Distillation (Corrected for Elevation)	
Up to 315 C	4.8%
315 to 355	12.6
Residue	82.0
Loss	0.6
Specific Gravity 100/60 F	0.962
Water content	0.5%
Flash point PMCC	115.5 C
PMCC	163.0 C

TABLE 2—TYPICAL SPECIFICATION OF CREOSOTE USED IN TRESTLE REPLICA TEST

Specific Gravity 38 C/15.5 C	1.071
Water content	1.3%
Coke residue	0.7%
Flash point PMCC	196 F
Insoluble in benzol	0.08%
Distillation (Corrected for Elevation)	
Up to 210 C	1.3%
210–235	4.7
235–270	26.4
270–315	24.7
315–355	23.0
Residue	19.1
Loss	0.8
Specific Gravity of Fractions	
A (235 C–315 C)	1.036
B (315 –355)	1.114

TABLE 3—RETENTIONS OF ARBAN 86 IN POUNDS PER CUBIC FOOT

	Outer	*Second*	*Third*	*Position in Bridge Replica*
Grease	0.25 in	0.25 in	0.25 in	Bottom of Fir Decking (8 bds.)
Pyroban B	1.77	0.81	0.65	Bottom of Fir Decking
Pyroban C	1.46	0.11	0.09	Bottom of Fir Decking
Pyroban B	1.87	0.33	0.32	Inside Fir Cap
Pyroban C	0.83	0.22	0.20	Inside Fir Cap
Pyroban B	4.32	1.50	1.22	No. 5 Piling—no bleeding
Pyroban B	4.51	1.20	1.20	No. 2 Piling—no bleeding
Pyroban C	2.68	0.64	0.30	No. 2 Piling—no bleeding
Pyroban C	1.31	0.39	0.48	No. 1 Pine Piling—dry side
Pyroban C	1.37	0.07	0.05	No. 1 Pine Piling—bleeding side

We also noted that the most persistent flaming always occurred in protected locations where entrapped heat could cause volatile materials to burn above the wood surface and away from the phosphate additive, thus indicating a need for a flame-controlling agent.

From the above, we have concluded that phosphorus as triaryl phosphate contributes materially to reduction of the fire hazard.

Phosphorus-halogen mixtures in the proper ratio to preservative solutions will increase the control.

Increased retention of preservative oil solutions increases fire hazard over low retentions.

A

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I would like to show you now some movies of some fire tests on full-scale replicas we have made.

The first one is a full-scale ballast-deck replica treated with a solution of 10 percent Santicizer–140 in 50/50 creosote–petroleum mixture. The Douglas fir lumber and piling was air seasoned to approximately 20 percent moisture content and were treated with the solution of 10 percent Santicizer in the 50/50 creosote–petroleum mixture. The Santicizer–140 is cresyl–diphenyl phosphate and contains about 9.2 percent phosphorus. The net retention of the piling was 20.56 lb per cu ft of the solution or 0.189 lb of phosphorus, and the net retention of the lumber was 15.18 lb per cu ft of the solution or 0.140 lb of phosphorus. Treatment of this replica was completed on March 19 and the test burning was started at 9:18 am May 5. The wind was NNW at 10 mph. The weeds were out in about 1½ min after the start. Temperature reached a peak of 1690 F 45 sec after start. At the end of 20 min all of the fire was out except two small pockets. The fire was completely out in 27 min with char on the piling from 1/16 to ⅛ in. The char on the lumber was ⅛ to ¼ in.

The next scene shows a full-scale replica which was coated with Pyroban C. The replica was made of fir lumber with southern pine piling treated with 50/50 creosote–petroleum mixture 2 to 10 years prior to test. It was sprayed with 23 gal of Pyroban C October 6 and 7. This covered approximately 500 sq ft with a thickness of coating approximately 0.0738 in. It was burned December 8, 1959, with a peak temperature of 1690 F.

The next scene is the testing of a replica treated with Pyroban B. This replica was made with Douglas fir lumber and piles treated with 50/50 creosote–petroleum mixture 2 to 10 years prior to test. The test structure was sprayed on October 6 and 7 with 19½ gal covering approximately 500 sq ft. The thickness of the resulting coat was approximately 1/16 in. The peak temperature was 1650 F. and the temperature was below 500 F. in 11 min 10 sec. The wind was rather brisk in this test. [Applause]

Chairman Schneider: Thank you, Mr. Collister, for a very interesting presentation, and also for the help you have been to this committee in study and research on the

subject of fireproofing wood bridges and trestles. I consider our committee very fortunate to have you collaborate with us.

Are there any questions that you would like to ask Mr. Collister on the subject of fireproofing, or on any of our reports? If not, Mr. Woolford, this concludes our report.

President Woolford: Thank you, Mr. Schneider, for your interest and effort in progressing the work of Committee 7 during the past year, for the reports which have been presented, and for the prospect of a number of interesting and informative reports one year hence.

And thank you, Mr. Collister, for explaining and portraying to us that immensely important work which has been done by your railroad in the development and testing of fire-retardant treatments for timber structures. Your railroad has led the way in this development and we on other roads have watched these developments with the greatest of interest and benefit.

Gentlemen, I might comment further that I was fortunate enough, in visiting the various committees over the last couple of years, to have been with Committee 7 when the Santa Fe put on one of these tests. I can assure you that it is awe-inspiring to see these bridges flame up and in a few minutes see the fire completely extinguished. I think it would be very interesting and informative for other railroads to see what the Santa Fe has done under Mr. Collister's direction. After I had viewed the test and studied it some, we thought so much of it that we adopted the treatment as standard for all of the creosoted bridges that we are building now. We think it is very worthwhile. It is something the American railroads can certainly use.

Mr. Schneider, your committee is now excused with the thanks of the Association. [Applause]

I would like to make an announcement. You will note from your program that at 3:45—and I hope we can be a little ahead of that—Committee 3 on Ties will give its presentation. Now, we have an additional presentation on ties, not a part of the presentation of Committee 3. Just recently, as you may have heard, a test installation of prestressed concrete ties has been made on one of the railroads down in the southeastern part of the country. The AAR Research Department covered this very thoroughly and I hope to gain enough time throughout the remainder of the morning and this afternoon so that any of you who would like to hear about this development can do so.

G. M. Magee, director of engineering research, AAR, here in Chicago, has interesting information on this test, and we would like to have him brief you while the "iron is hot."

I want to remind you again that we will try to get this report in today. We hope we can do it without running into overtime. If not, we will run overtime this evening in order to give you some factual information about these prestressed concrete ties.

Discussion on Masonry

[For report see pp. 461–489.]

[President Woolford presiding.]

President Woolford: Our next structural committee to report is Committee 8—Masonry. The chairman of this committee is E. A. McLeod, assistant bridge engineer, New York Central System, New York. Mr. McLeod, if you and the other members of your committee will come to the platform, we would be pleased to hear your report at this time.

Chairman E. A. McLeod: Mr. President, members of the Association and guests:

Early this year, your committee lost one of its valued members, A. E. Hotard, assistant bridge engineer, Louisville & Nashville Railroad, and chairman of our subcommittee on precast concrete. We have also lost one of the key men of the AAR research staff, P. D. Meisenhelder, research engineer concrete, who had been expected to deliver an address at this meeting today. Memoirs have been prepared for each of these men for publication in the 1960 Volume of the Proceedings.

MEMOIR

Albert Etienne Hotard

It is with deep regret and sorrow that we, the members of Committee 8—Masonry, record the passing of one of our members, Albert Etienne Hotard, assistant bridge engineer, Louisville & Nashville Railroad, Louisville, Ky.

Mr. Hotard was born in New Orleans, La., on July 26, 1923, and passed away on January 5, 1960, after a short illness.

He was graduated in civil engineering from Tulane University in June 1945, and entered the service of the Louisville & Nashville in the same month and year as instrumentman. Promotions followed rapidly, both in the field and in the chief engineer's office. In October 1956, he was advanced to assistant bridge engineer, which position he held at the time of his death.

Mr. Hotard joined the AREA in 1957 and became a member of Committee 8 in 1958. He was also a member of the American Railway Bridge and Building Association, a devoted member of the Official Board of Buechel Methodist Church and a member of the Optimist Boys' Club.

Mr. Hotard is survived by his wife, Judith E. Hotard, and two children, Steven and Judith Anne Hotard.

He will be remembered by his colleagues for his willingness to give freely and wholeheartedly of his time and efforts to further committee goals, and for his friendly relationship with everyone who knew him.

MEMOIR

Paul D. Meisenhelder

Paul D. Meisenhelder, research engineer concrete, Association of American Railroads, Chicago, died on November 14, 1959.

Mr. Meisenhelder was born in Palestine, Ill., on April 20, 1895. He was a graduate of Purdue University, receiving a BS degree in Civil Engineering in 1917 and a CE degree in 1924. Immediately after graduation, he entered the U. S. Army and served two years during World War I as a lieutenant in the Corps of Engineers. Following the war he worked for the Indiana State Highway Commission continuously, except for short periods of time when he was with the Purdue University Engineering Experiment Station, until March 1934. The early portion of this time was spent partly on construction work but mostly in the Bureau of Tests. During the last nine years he was in charge of the Bureau.

He spent the period from 1934 to 1946 with the PWA, in consulting work in the field of materials, and on construction work, including sewerage treatment plants, water supply facilities, bridges and buildings. In 1946 he returned to the Indiana State Highway Commission as engineer of materials and tests, and in 1949 became associated with the Pennsylvania Turnpike Commission as assistant materials engineer. He joined the staff of the Association of American Railroads on April 16, 1951, as concrete engineer and later became research engineer concrete, in which capacity he served until his death.

He was a registered professional engineer in Indiana, a member of the American Society of Civil Engineers, the American Society for Testing Materials, and the American Concrete Institute. He had served on ACI Committee 201—Durability of Concrete, and Committee 611—Inspection of Concrete. His ASTM committee affiliation was with Committee C-1 on Cement and Committee C-9 on Concrete and Concrete Aggregates. He also served on American Standards Association Committee A1—Specifications and Methods of Test for Hydraulic Cements.

With the Association of American Railroads, he actively supervised research sponsored by AREA Committees 8—Masonry, and 29—Waterproofing. For Committee 8, his efforts were directed toward determining the causes of concrete deterioration of railway structures, to improve the durability of new concrete construction and to develop economical methods of repairing concrete structures. With Committee 29 he assisted in the development of suitable waterproofing paints and membranes for concrete surfaces.

Those closely associated with Mr. Meisenhelder will long remember his friendly interest and competent understanding of their common problems, and feel a great personal loss in his passing.

Chairman McLeod: Committee 8—Masonry, is reporting on three assignments. The reports will be found in Bulletin 554, December 1959, starting on page 461.

Assignment 2—Design of Masonry Structures, Collaborating with Committees 1, 5, 6, 7, 15, 28, 29, and 30.

Chairman McLeod: Subcommittee Chairman J. U. Estes, associate bridge engineer, Louisville & Nashville, will now present the report on Assignment 2.

J. U. Estes: Mr. President, members and guests:

Last year your committee presented as information a tentative draft of Specifications for Design and Construction of Reinforced Concrete Trestles for Railway Loading (Proceedings, Vol. 60, 1959, pages 474 to 488, incl.) and invited comments and criticisms thereon. Minor revisions have been made as indicated on pages 462 to 464, incl., of Bulletin 554.

Mr. President, I move that these specifications, with the minor revisions, be adopted to replace material withdrawn from Part 9, Chapter 8, of the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

J. U. Estes: Your committee also recommends the adoption of the revisions and additions to the Specifications for Design and Construction of Reinforced Concrete Box Culverts, Part 16, Chapter 8, as shown on page 465 of Bulletin 554. Mr. President, I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 5—Tunnel Linings: Design, Construction and Maintenance, Collaborating with Committees 1, 5, 17, 28, and 29.

Chairman McLeod: Subcommittee Chairman G. H. Dayett, Jr., assistant maintenance engineer, Baltimore & Ohio, will present the report on Assignment 5.

G. H. Dayett, Jr.: Your committee submits a report on leakage in tunnels and method of correction, as information. This report appears in AREA Bulletin for December 1959, Vol. 61, No. 554, page 465.

In correcting a water problem attempts should be made to open existing weep holes and drains.

To determine the best location for new drains, holes should be drilled through the lining at the wet area in an effort to tap the water. These holes should be drilled as near the ditch line as practical. If the holes that drain water are not over 4 ft above top of rail they should be enlarged a minimum of 3 in, preferably with soil pipe grouted in place with exposed end extending beyond the inner face of the lining. When holes are higher than 4 ft above top of rail consideration should be given to cutting a recessed drain in the tunnel lining.

Seepage in joints or cracks may be sealed by caulking with oakum or lead wool and covering with gunite, or as shown in Fig. 1, page 8–13–3, of the Manual.

Pressure grouting back of the tunnel lining may seal some areas that are wet or drive the water to a point of concentration where a drain may be cut.

In brick-lined tunnels the seepage of water in a straight horizontal line, especially in the quarters of the arch, indicates the arch may be cracked and other repairs may be needed.

Very often leaks near the end of the tunnel are due to clogged portal drains and weathered material forming a catch basin over the portal that caused water to seep back into the tunnel.

Generally, it is best to open portal drains, clear drainage ditches above the portal, and consider a concrete apron in connection with any remedies that may be taken inside the tunnel.

President Woolford: Thank you, Mr. Dayett. Your report will be received as information.

Assignment 6—Prestressed Concrete for Railway Structures, Collaborating with Committee 6.

Chairman McLeod: Subcommittee Chairman D. H. Dowe, assistant engineer of bridges, Seaboard Air Line, will present the report on Assignment 6.

D. H. Dowe: Mr. President, members and guests of the Association: Your committee presents as information a tentative draft of Specifications for Design, Materials and Construction of Prestressed Concrete Structures, and requests comments and criticisms thereon, with the thought that these specifications be presented next year for adoption and publication as Part 17 of Chapter 8 in the Manual.

It is requested that any comments or criticisms be in the hands of the committee not later than May 1 in order that the committee may take action for approval at its May meeting.

President Woolford: Thank you, Mr. Dowe. Your report will be received as information.

Gentlemen, may I make a few comments here. This I think is a very important subject. Please cooperate with Mr. Dowe and let him have the benefit of your comments and criticism. It is most important to all of us, this subject of prestressed concrete for railway structures.

Chairman McLeod: We have not reported on a few assignments. Under Assignment 3—Foundations and Earth Pressures, crib wall specifications are being reviewed. Under Assignment 7—Quality of Concrete and Mortars, Manual Chapter 8, Part 1, is

being reviewed; and under Assignment 10—Methods of Construction with Precast Concrete Structural Members, a report has been prepared but is receiving further consideration.

Committee 8 has joined with Committee 30 in a special feature, a symposium on prestressed concrete, which will be presented with the report of Committee 30.

Mr. Woolford, this concludes the report of Committee 8.

President Woolford: Thank you, Mr. McLeod. All of us on the railroads look to your committee for the latest developments and recommended practices in concrete design, construction and maintenance, and we are especially glad to see your committee come up this year with a tentative draft of Specifications for Design, Materials and Construction of Prestressed Concrete Structures. Some of us are going into this type of construction, recognizing the great number of advantages over normal reinforced concrete, and we need the very best thinking of your committee on this subject. I hope that you will find it possible to develop these specifications to the point where they can be offered for adoption at our next convention. We have great hopes for standardization in this development. Others are doing it, there is no reason why we cannot. Prestressed concrete lends itself to standardization of our regular bridge structures, our overpasses and many others, so I hope that your committee will work on this most diligently and come up with good specifications and recommendations for standardization.

Hurrying along, as we must, being anxious to get to your Symposium, jointly with Committee 30, on The Application of Prestressed Concrete to Railway Structures, I will now excuse your committee with the thanks of the Association. [Applause]

Discussion on Impact and Bridge Stresses

[For report see pp. 429–433.]

[President Woolford presiding.]

President Woolford: I shall be glad if the members of Committee 30—Impact and Bridge Stresses, will please come to the speaker's table and present their report. The chairman of this committee is D. W. Musser, design engineer of the Erie Railroad, and without further comment, as soon as Mr. Musser comes to the podium, I will turn it over to him, so we can get along as fast as possible.

Chairman D. W. Musser: Mr. President, members of the Association, and guests:

Committee 30 began the past year with 11 assignments and we have completed one of these, Assignment 1—Steel Girder Spans. Next year we will complete another of our assignments, Assignment 5—Distribution of Live Load in Bridge Floors.

Seven of the committee's 11 assignments are reported on this year in Bulletin 554, pages 429 to 433. They are all progress reports except for Assignment 1, which is a final report.

Assignment 1—Steel Girder Spans.

Chairman Musser: I will not say much about the results of Assignment 1, as our subcommittee chairman, M. J. Plumb, will give a full report on this important assignment in a few minutes. However, I do want to point out that the impact equations that your committee has suggested are based on many thousands of recordings on 37 different through and deck-type girder spans ranging in length from 40 ft to 140 ft, of both the open-deck and ballast-deck type, and loaded with both diesel and reciprocating-type engines. The rating of these engines varied from E 21 to E 70.5, and

they moved over the test spans at speeds varying from about 5 mph to about 100 mph. It is evident that the tests were very complete, and we feel the results are very significant, as bridge engineers will be able to design structures with more confidence and a better knowledge of their behavior when acted upon by moving loads.

M. J. Plumb, of Plumb, Tuckett & Hubbard, consulting engineers, who is chairman of Subcommittee 1, will now give the report on Assignment 1.

M. J. Plumb: Mr. President, members and guests of the Association: we are pleased to have published this year a summary report of the tests on steel girder spans.

The proper provision for impact in railway bridges has been a matter of concern to railroad bridge engineers for many years. We still use the term "impact", although a more precise term would be "dynamic effect of moving loads."

Earlier efforts at measuring impacts were hampered by the lack of reliable instruments for measuring stresses in steel. Various types of mechanical strain gages were developed and used, but deflectometers proved more accurate. Thus the earlier tests of impact either recorded strains with mechanical gages or recorded deflections with deflectometers, or both.

In 1910 your Association adopted new impact formulas based on tests conducted by the Committee on Impact under the direction of Dean F. E. Turneaure. Important contributions, based on extensive theoretical studies and field tests, were made to our understanding of impact by India in 1925 and by the British in 1928. In 1935 your Association adopted revised impact formulas based on deflection records from tests conducted under the direction of J. B. Hunley. In 1940 your Association purchased some electromagnetic strain gages and embarked on the present series of tests. The summary report presented today is the final report on girder spans. Considerable work remains to be done on truss spans.

These electronic strain gages provided for the first time reliable measurements of the actual static and dynamic strains in structural members under moving loads.

The results of these tests not only prove the inaccuracy of the results from mechanical strain gages, but they also prove that deflections are not a reliable indication of dynamic stresses.

In 1948 your Association, for the third time this century, made a major revision in the impact formulas. This change was based on preliminary results from these tests using the new electronic gages and generally increased the required impact values, particularly on longer spans and with diesel loadings.

This report summarizes the results of a tremendous number of tests with very accurate instruments. More exhaustive tests could be expected to substantiate and refine the results but there is little likelihood they would change.

Based on these tests, your committee has suggested a further revision of the impact formulas. This revision has a number of important advantages. First, it was found that ballasted-deck bridges have very definitely less impact than open-deck bridges. It would seem reasonable to take advantage of this fact and obtain some economy without sacrifice of safety.

Second, it was discovered that the present requirements for roll effect impact do not agree with measured results. One of the most frustrating experiences in the life of a railroad bridge designer is to calculate the roll-effect impact on a deck-beam structure and then try to get another engineer to agree with the results. You must assume that diaphragms are indefinitely rigid or that they have no rigidity. A more simple provision for roll effect can at the same time be more accurate.

Before the Iron and Steel Structures committee can recommend any new impact formulas for girder spans to you for your approval, they will have to consider their relation to the impact formulas for truss spans, and they should make different provision for reduced impact at slower speeds in the Rules for Rating Existing Bridges.

I would like to pay tribute to the AAR research staff who have done a magnificent job, under the direction of Emerson Ruble and Freeman Drew, in analyzing a mountain of records and presenting the results in such a way that you and I can understand them and make use of them.

This is a final report, presented for information.

President Woolford: Thank you Mr. Plumb. Your report will be so accepted.

Chairman Musser: I shall now comment briefly on our other reports.

Assignment 4—Longitudinal Forces in Bridge Structures, Collaborating with Committees 7, 8 and 15.

Chairman Musser: Data on the behavior of longitudinal forces in bridge structures are continually being collected in connection with our tests on railroad bridges. These data have been reported from time to time, and it is the committee's intent to continue this practice until such time as sufficient information has been gathered to present a comprehensive final report on longitudinal forces in bridge structures. The latest information reported was that obtained in connection with the tests on timber trestles on the Santa Fe Railway, reported under Assignment 7. In these tests, as in previous ones, it was found that while quite large longitudinal forces are generated, particularly at the instant of braking to a stop, practically all of the force is resisted by tensile and compressive stresses in the running rails.

Assignment 5—Distribution of Live Load in Bridge Floors.

Chairman Musser: When Assignment 5 is concluded, we shall have taken another step forward in our search for the true behavior of a structure supporting a moving live load. Our present equations for the distribution of live load in bridge floors are empirical and have no theoretical background. However, with the conclusion of this assignment, we hope that we will be able to correlate our test results with a theoretical analysis and will be able to write an equation that will more realistically determine the distribution of live load in bridge floors. This should bring about a saving of many thousands of dollars a year to the railroads.

The current work on this project is being done at the University of Illinois, where during the last year they have evaluated the analytical procedures that have been selected to determine the beam moments and the use of these procedures to obtain a large number of solutions for various floor systems.

Two analytical methods have been used to determine the beam moments in the bridge structures. One is based upon an orthotropic plate theory and assumes the beams and the slab to be an integral unit. The second procedure is a moment distribution method of analysis and assumes no horizontal shear transfer between the floorbeams and the slab.

Nearly all of the analytical results have been obtained, and in most instances have provided excellent correlations with the data from the bridge tests reported previously by this committee.

Assignment 6—Concrete Structures, Collaborating with Committee 8.

Chairman Musser: All of our work currently in progress or in the planning stage for concrete structures is in the field of prestressed concrete. This rapidly growing field

of engineering has caught the imagination of many railroad engineers and is rapidly becoming a major tool in their hands. The symposium which Committees 8 and 30 will present in a few minutes will illustrate this.

One of the major unanswered questions in prestressed concrete is "What is the fatigue resistance of prestressed concrete?" Much of the work we have done in the past and most of the work that we have programmed for the future is based on this question. We hope that when the present program of work is completed, we will be able to answer many of the questions on fatigue in prestressed concrete.

We are also continuing our program of field testing prestressed concrete structures. The AAR research staff is at present preparing a report of tests conducted on a prestressed concrete bridge on the Southern Railway. This report will be published sometime this next year. The AAR has also conducted tests on a Santa Fe Railway prestressed concrete bridge, and the analysis of the recordings is now being progressed.

Assignment 7—Timber Structures, Collaborating with Committee 7.

Chairman Musser: The second in a series of reports on timber trestles was published this past year. The report covers the investigation of four single-track ballasted-deck pile trestles on the Santa Fe Railway. These bridges were selected because the low relative humidity in the area insured low moisture content in the wood.

The results of these tests bore out the conclusions that were reached in the Seaboard Air Line tests, namely, that decks of trestles having alternate stringers which are continuous over the bents act as a partially continuous structure, and that cumulative loading time of cars in trains appears to be greater at all stress levels than that of the diesel locomotives. However, a great deal of field work and analysis must be conducted before sufficient data are available from which to draw general conclusions on actual stresses in timber structures as compared to design values.

Assignment 9—Use of Electronic Computers for Railroad Bridge Problems.

Chairman Musser: Early in 1959, a computer program for calculating shears, moments, floorbeam reactions and Cooper E ratings for any system of moving loads on simple spans was completed and was made available to Member Railroads. This program can be used to calculate moments and shears and will be used as part of future programs for bridge rating or stress-analysis problems.

This same program has been used to prepare moment and shear tables for about 25 representative special, heavy railroad cars. These tables will provide a handy reference and valuable assistance to bridge engineers in their calculations to determine whether heavy cars can move over their bridges. The tables are now being completed and will be made available to the railroads very soon.

Assignment 10—Steel Continuous Structures, Collaborating with Committee 15.

Chairman Musser: Field tests were conducted by the research staff of the AAR on three continuous-span bridges on the Southern Pacific Company in 1957. These bridges are on the main line near Redding, Calif., and are: (1) Bridge No. 282.93, three 40-ft ballasted-deck plate-girder spans. (2) Bridge No. 283.77, three 192-ft 6-in open-deck riveted truss spans. (3) Bridge No. 284.16, two 46-ft 8-in ballasted-deck through-plate-girder spans.

The test data have been analyzed and a report has been prepared by the research staff of the AAR and reviewed by this committee. The report will be published sometime this summer.

This completes the brief resumé of our current work.

I would now like to introduce the subcommittee chairmen who are responsible for the work this committee is doing. As I give their names, I ask that each chairman stand, in order that he may be recognized.

M. J. Plumb, Plumb, Tuckett & Hubbard, consulting engineers, Subcommittee on Steel Girder Spans.

E. S. Birkenwald, engineer of bridges, Southern Railway System, Subcommittee on Steel Truss Spans. I understand Mr. Birkenwald had a fire in one of his trestles and is not able to be here today.

Dean A. T. Granger, College of Engineering, University of Tennessee, Subcommitee on Viaduct Columns. Dean Granger is not here today.

J. A. Erskine, assistant bridge and building engineer, Gulf, Mobile & Ohio Railroad, Subcommittee on Longitudinal Forces. Mr. Erskine is not here today.

Dr. N. M. Newmark, Department of Civil Engineering, University of Illinois, Subcommittee on Distribution of Live Load.

P. L. Montgomery, assistant designing engineer, Nickel Plate Railroad, Subcommittee on Concrete Structures.

C. V. Lund, assistant to chief engineer, Milwaukee Road, Subcommittee on Timber Structure.

Dr. James Michalos, Department of Civil Engineering, New York University, Subcommittee on Vibrational Characteristics.

E. R. Andrlik, bridge designer, Santa Fe Railway, Subcommittee on Electronic Computers.

A. R. Harris, engineer of bridges, Chicago & North Western Railway, Subcommittee on Continuous Structures.

N. E. Ekrem, assistant bridge engineer, Great Northern Railway, Subcommittee on Composite Design.

Symposium on Application of Prestressed Concrete to Railway Structures

Chairman Musser: This concludes our formal submission of reports. However, we have one more presentation, our Special Feature, which we are jointly presenting with Committee 8—Masonry. It will be a Symposium on Application of Prestressed Concrete to Railway Structures. E. J. Ruble, research engineer structures of the AAR, will act as moderator and will introduce the participants. Mr. Ruble.

E. J. Ruble: Mr. President, members and guests:

We hear a great deal about prestressed concrete today and it is generally considered as being new, but actually the method is as old as conventional reinforced concrete. Our forefathers were using the principle of prestressing when they placed the steel tires on their covered wagon wheels. As far as I know, the first patent in connection with prestressed concrete was issued in 1888 to a Mr. Jackson in San Francisco. This patent covered the fabrication of prestressed concrete fence posts. However, the principle could not be applied to concrete structures until about 1927, when steels having high yield points and concretes having high ultimate strengths came into use.

I have a model here with which I think I can demonstrate the principle of prestressed concrete, if we look at it as a concrete member. We all know that concrete is very weak in tension, strong in compression. If we place these bottom fibers in compression, we can make a very good beam. What I have done has been to place the

The second span from the left of this CB&Q Railroad bridge is the first prestressed concrete railroad in the United States and has a length of 19 ft.

lower fibers in compression with, in this case, a spring, but actually we use high-strength steels which have spring characteristics. Now (if you will hold that end), we see that it carries a lot of load, and if we do crack the beam, it will fly right back. That is the principle of prestressed concrete.

In the other method of prestressing concrete, called pretensioning, we stress the wire first and then pour the concrete around it; and after the concrete has reached sufficient strength, we release the wire.

We have a few slides to demonstrate the growth of prestressed concrete, and I would like to show these slides at this time.

The first prestressed concrete railroad bridge was built in Brussels, Belgium, in 1942. This was an experimental bridge and consisted of 66-ft spans.

The first bridge in this country is the Walnut Lane Bridge in Philadelphia. This bridge has a 160-ft center span and was started in 1949.

The first railroad bridge of prestressed concrete in this country is on the Burlington near Honeywell, Mo. This bridge was built in 1954 and consists of two slabs under the track, each 18 ft 9 in, center to center of bearings. This bridge, of course, was built after extensive laboratory investigation of prestressed concrete members.

The 26-ft span on the Southern Railway near Lynchburg, Va.

The AT&SF Railway bridge on a line through the Air Force Academy near Colorado Springs, Colo., has 72-ft girders.

The 25-ft beams on the Western Pacific Railroad near Stockton, Calif., are supported on prestressed concrete piles.

Another prestressed concrete bridge is the Santa Fe bridge near Colorado Springs. This bridge was built on a line change necessitated by the construction of the Air Force Academy. It was built in 1957 and has a span of 69 ft 10 in, center to center of bearings. This bridge consists of two girder spans per track. This is another view of the Santa Fe bridge at Colorado Springs. Incidentally, we conducted extensive tests on this bridge, which will be reported in the near future.

This is a Santa Fe bridge at Colton, Calif. There are two spans, each 34 ft long. The beams are 48 in wide by 38 in deep, with center voids.

This is a bridge on the Chicago & North Western which was built in 1958. The span is 36 ft 6 in long, and you will note from the sketch in the lower left-hand corner the type of construction.

This bridge is on the Southern Railway at Dry Forks, Va. There are three 27-ft spans, built in 1957. The beams are 29 in square, with center voids.

This bridge is on the Western Pacific near Stockton, Calif. I imagine Mr. Woolford recognizes this view. It was built in 1959 and has 25-ft spans with prestressed concrete piles. This is a view of the pile bents. Each pile is 20 in, octagonal, and hollow.

This is another view looking down the track, showing the hand rails.

This shows some typical prestressed concrete piles for a railroad bridge in the Norfolk area. These particular piles, of course, are square but, as previously mentioned, Mr. Woolford had some octagonal ones. Either type is satisfactory.

This is a prestressed concrete car building on the Boston & Maine Railroad in Boston.

Here we have a prestressed concrete retarder tower on the C&O. The type of construction here consists of two prestressed slabs joined together.

This is another prestressed concrete retarder tower on the Western Pacific.

Here we have another use of prestressed concrete, for snow-fence planks. These planks are 1 in thick, 12 in wide and 13 ft long, and they weigh 100 lb each. They can easily be carried by two men.

I have three slides here showing some of the typical bridges in Europe which I think are representative of European bridges. This bridge is the 160-ft girder span over the River Dorn at Rotherham, England, and was built in 1953. You can see it is a through-girder type of construction with a prestressed concrete deck.

Here we have a bridge with 150-ft girder spans over the Isar River in Munich. It was built in 1953.

Here we have a 351-ft span over the Neckar Canal at Heilbronn, Germany. This happens to be a highway bridge, but it certainly represents the bridges of Europe.

We have asked four men to give us papers on prestressed concrete, and at this time I would like to introduce Dr. C. E. Ekberg, professor, and head of the Department of Civil Engineering of Iowa State University, a member of Committee 30, and the son of Mr. Ekberg, bridge engineer of the Northern Pacific Railway. Dr. Ekberg will discuss research on prestressed concrete members. Dr. Ekberg.

Application of Prestressed Concrete to Railway Structures—Research

By Dr. C. E. Ekberg, Jr.

Professor and Head, Department of Civil Engineering, Iowa State University

The combined efforts of the engineer and research worker has produced, during the past 8 or 9 years, three established outlines of procedure for the design of prestressed concrete bridge members. In chronological order, these are: (1) "Criteria for Prestressed Concrete Bridges," published by the Department of Commerce, Bureau of Public Roads, 1954. (2) "Tentative Recommendations for Prestressed Concrete," published by the ACI–ASCE Joint Committee 323. (3) "Specifications for Design, Materials and Construction of Prestressed Concrete Structures," prepared by AREA Committee 8.

Conventional prestressed concrete designs for simple beams are now handled with confidence by many engineers. Furthermore, it appears that this form of construction has taken a definite place in the short-span bridge field. This is especially true in highway construction where precast prestressed beams up to 100 ft in span have been employed. Many problems still exist, though, for the producer of these units. His primary task is to promote enough uses for his prestressed concrete, so that he can keep his facilities busy. He has, generally speaking, a heavy investment in his plant, and the bridge business alone is not sufficient. The facts are that there is keen competition in most areas among manufacturers of prestressed concrete, and the product is of consistently high quality.

In my opinion future research should follow two courses: First, it should be aimed at refinements in the existing design procedures. Secondly, it should aid in developing new designs and uses for prestressed concrete.

Several refinements in our design procedures are needed in order that structures will perform in a more satisfactory manner. For example, further investigations of creep effects in both steel and concrete are needed. Other areas of interest include studies to extend our knowledge of fatigue resistance, and resistance to combined shear and bending stresses.

Creep effects are manifest primarily as changes in vertical displacement, and as changes in length. Changes in vertical displacement (or camber) can cause trouble in a bridge in several ways, depending on the particular design. For instance, two adjacent beams may not properly match if there are variations in camber due to prestressing. Length changes can cause trouble at the supports where relative movement may prove harmful, depending again upon the design. Much is already known about creep, in both concrete and steel, but the matter of applying this knowledge to the case in question is a difficult one, as many variables are involved.

Fatigue resistance, or the resistance of a bridge to repeated loads, is an important problem to the railroad bridge engineer. There is a possibility, of course, for a great number of overloaded cars to move over a given structure during its useful life. Data on fatigue are already available from past work, part of which has been conducted under the auspices of the AREA.

Studies of beam resistance to combined shear and bending are very important, but they are also very difficult to draw useful conclusions from. Whereas the problem of computing the ultimate strength in bending of a beam was solved several years ago, the problem becomes much more complex when the effects of loading in fairly close proximity to the supports is considered. Furthermore, the aspect of fatigue may enter to further complicate the situation.

The second possible course of research, namely, that which aids in developing new applications and designs is, extremely interesting as well as challenging. The possibilities of partial prestressing is especially intriguing. A partially prestressed section is one which is designed so that under working load some tensile stresses are produced in the member. In such cases it is customary to provide conventional reinforcing bars to minimize cracking tendencies. Such a section would have the advantage of a lower total prestressing force which would lessen creep effects, but under dead load alone the prestress would be sufficient to close the cracks completely. New prestressed precast products which have appeared are light poles, piles, and railroad ties. Two new materials have entered the scene and may have a beneficial impact on the prestressed concrete industry. These are epoxy resins and improved lightweight aggregates. Epoxies can be used to permanently join separate precast units together; however, they are virtually untried and untested at present. Lightweight aggregates are slowly making their presence felt, but here again there is need for more investigation coupled with keen observation of performance. [Applause]

Mr. Ruble: Thank you, Dr. Ekberg.

Our next speaker is L. P. Nicholson, railway representative, Portland Cement Association, and a member of both Committee 8 and Committee 30, who will discuss the concrete and steel materials used in prestressed concrete.

Application of Prestressed Concrete to Railway Structures—Materials

By L. P. Nicholson

Railway Representative, Portland Cement Association

Prestressed concrete requires the use of considerably higher strength concrete and steel than is normally used for conventionally reinforced concrete. This is necessary to maintain a reasonable stress level after creep, shrinkage, and other losses have reduced the effects of initial prestressing.

Although the ultimate capacity of the usual member is dependent on steel rather than concrete strength, the behavior at service loads and the dimensions of the member are a function of the concrete strength.

For this reason, most designs are based on what might be termed a high convenient concrete strength, that is, the high strength that can be readily achieved under a wide range of local conditions and aggregates. For example, the requirements for the two 70-ft span prestressed railroad bridges built for the Santa Fe Railway in Colorado were 4500 psi compressive strength of air-entrained concrete at the time of initial prestress, and 5500 psi at 28 days.

Girders with these concrete strengths of 5000 to 6000 psi may not cost more per unit of resisting capacity. That this is so can readily be visualized by comparing 3000-psi concrete to 6000-psi concrete. The cost of the 6000 psi concrete is approximately 20 percent more than for the 3000-psi concrete. But how about strength? For this 20 percent cost premium our strength has increased 100 percent.

For plant-made and most field-made products, it is desirable to produce these high strengths as quickly as possible to allow early release of forms and tensioning devices for reuse. It is well established that higher strengths are produced by lowering the water–cement ratio and that the amount of shrinkage is dependent on the unit water content (gal/cu yd). Aside from higher strengths, a properly designed high-strength concrete mix using a low unit water content has the advantage of lower shrinkage with corresponding reduction in the loss of prestress due to shrinkage.

How do we lower the water content in concrete? By using larger-size aggregates, better-graded aggregates and stiffer consistencies. As for all concrete work, well-graded aggregates up to the maximum size aggregate that is practicable to use is required in prestressed work. Also stiff consistencies, or low-slump concrete as it is termed, are required. Usually less than 4-in slump is used and in many instances "no-slump" concrete is used. One products manufacturer has coined a new slump designation "negative 2." By this term he refers to concrete in which enough water to cause 2 in of slump could be added without producing any slump.

Because aggregates comprise a large fraction of the volume of concrete, the characteristics of the aggregate influence the properties of the concrete. Mineral composition and soundness of the aggregates have a marked influence on compressive strength, modulus of elasticity, drying shrinkage and creep. However, if the aggregates meet the Specifications for Concrete Aggregates (ASTM Designation C 33) or Specifications for Lightweight Aggregates for Structural Concrete (ASTM Designation C 330), they will be suitable for use in prestressed concrete.

Steel for prestressed concrete must have high tensile strength and adequate ductility to provide and maintain the internal compressive concrete stresses. Such steel can take any of four forms: wire, cables, strands or rods. Wires, cables and strands have ultimate strengths in excess of 250,000 psi and are stressed initially up to 70 percent of the ultimate strength, which would be 175,000 psi. Rods have ultimate strengths up to 150,000 psi. Most manufacturers of pretentioned prestressed concrete products use 7-wire strands from ¼ to ½ in. in diameter, although some use single wires from 0.08 to 0.27 in. in diameter.

For post-tensioning work, steel is available in rods, groups of wires made into cable, or in galvanized strands. Since the steel is anchored at the end face of the beam in post-tensioning systems, numerous end anchorages have been developed. Two fundamental ideas are prevalent—mechanical holding, such as threaded units or headed units; and friction or wedge devices.

In conclusion, I want to state that if the materials used in the manufacture of prestressed concrete comply with the materials section of the prestressed concrete specification that Committee 8 has just presented at this convention, no difficulty should be encountered as to proper and adequate materials for prestressed concrete. [Applause]

Mr. Ruble: Thank you, Mr. Nicholson.

Our next speaker is W. R. Wilson, assistant bridge engineer—system of the Santa Fe Railway, a member of Committee 8 and a former chairman of the committee. Mr. Wilson will discuss design features of prestressed concrete. He is well qualified to talk on this subject, as he helped draft the new specification for such members. Mr. Wilson.

Application of Prestressed Concrete to Railway Structures—Design

By W. R. Wilson
Assistant Bridge Engineer—System, Santa Fe Railway

We are all more or less familiar with the design of simple-span bridges of steel or reinforced concrete in which we apply dead load, live load and impact to the bridge member and then determine the stresses produced by these loads. The design procedure for prestressed concrete bridge members follows the same general pattern, using the familiar elastic theory, but there are more stress combinations to consider and more design stages to investigate.

The method of design is outlined in the report of the ACI–ASCE Joint Committee 323 on "Tentative Recommendations for Prestressed Concrete" published in January 1958. These recommendations were followed by Committee 8 in its preparation of "Specifications for Design, Materials and Construction of Prestressed Concrete Structures", just presented to the Association, with such modifications as were deemed necessary because of the heavier railroad loadings.

In an ordinary prestressed design problem, the following loading stages have to be considered:

1. Initial prestress, especially at the supports where the moment is zero, and high tension can develop in the concrete at the top of the beam. This stage of the loading usually causes the highest stresses that the member will ever receive.
2. Prestress plus the dead load of the member itself.
3. Transportation and erection stresses which could be excessive and cause self-destruction of the beam if not carefully considered.
4. Additional dead load as required to complete the structure. This is the case of a bridge using precast beams with a deck cast integral with these beams.
5. Superimposed live load plus impact.
6. Load required to develop the first crack. In the foregoing design assumptions, tension in the concrete was taken into consideration, and the normal loading should be such as not to produce cracks. An occasional overload of a temporary nature can be allowed and while this causes cracking, the cracks will close up after the passage of such a load.
7. Ultimate load. Members designed for loads less than those producing cracking act according to the elastic theory, and stresses are linearly proportional to external forces and moments throughout this range. After cracking, the stresses are not necessarily proportional to the additional loads applied.

Consequently, to insure a proper factor of safety, ultimate load factors are applied to the design load and the ultimate capacity of the member is computed. If the member as designed will not carry the ultimate load, it must be increased in strength so that it can. The ultimate load factors specified by Committee 8 take into account future ballast increases, and the totals are such as to give an overall factor of safety in excess of 2.

The design should be such that failure at ultimate load, theoretically, shall be by elongation of the prestressing steel. This is to insure plenty of warning of impending failure, since many cracks would be observed in the bottom of the member long before failure is imminent. If the prestressing steel is over designed, compressive failure would take place in the concrete and could occur without any warning.

Due to the high stress initially placed in the prestressing steel, an upward camber is produced in any prestressed member. This camber can be controlled somewhat by the location of the steel and should always be considered in the design.

Shear is computed under ultimate load, and the design of web reinforcement is based on ultimate strength with the effect of the prestressing considered. The prestressing forces are combined with the direct shear which will generally reduce the diagonal tensile stresses considerably below those computed for a reinforced concrete member.

By following the design specifications submitted by Committee 8 and taking into consideration all points covered therein, a designer should be able to produce a safe and economical prestressed concrete bridge. [Applause]

Mr. Ruble: Thank you, Mr. Wilson.

Our next speaker was supposed to be P. S. Gillan, general manager for the Florida Prestressed Concrete Company. Is Mr. Gillan on the floor? Mr. President, Mr. Gillan was supposed to be here, but we tried to locate him all morning and have been unable to do so.

President Woolford: We are sorry he isn't here, Mr. Ruble, but we need the time.

Mr. Ruble: I thought you could use the time. However, I have a copy of Mr. Gillan's paper and shall give it to Secretary Howard for inclusion in the Proceedings.

Application of Prestressed Concrete to Railway Structures—Construction

By P. S. Gillan

General Manager, Florida Prestressed Concrete Company

The introduction of prestressed concrete into the American construction market has triggered an unbelievable amount of investment in this relatively infant industry. This new material is available to the construction field in products for varied use in residential work and for the heaviest type of construction. We now consider that the construction field has three basic structural materials; steel, reinforced concrete, and prestressed concrete. I purposely omit timber because of its dwindling use in structural systems.

One example of the rapid growth of the prestressed concrete industry is reflected in the following comparison: In 1950, the number of prestressed concrete plants in the United States numbered less than five, while today, as best can be determined, there are more than 200 such plants. It might be interesting to note that the State of Florida contains 19 of these plants.

There are two basic methods of prestressing a concrete member. First, there is the pretensioning method. This is the method referred to when the prestressing reinforcement is first elongated (or stressed) and then anchored. The concrete is then poured around this reinforcement and allowed to obtain its strength before the prestress is released into the member. Second, there is the post-tension method. This is so called because the concrete is first poured and the prestressing is then accomplished after the concrete has reached the desired strength.

Each method has its advantages and disadvantages and must be considered individually in the light of the specific member under consideration. It is generally felt by the manufacturers of prestressed concrete that it is more economical to pretension a member than to post tension the same member. Many factors, such as amount of prestressing, length of member, and design requirements will affect the authenticity of this statement.

Post tensioning allows the prestressing reinforcement to be draped in a pattern where actually required in the member, whereas until recently, pretentioning reinforcement was placed in a straight line pattern throughout the length of the member. This latter application, at times, causes serious end beam conditions that actually can restrict its use beyond certain limits.

A recent modification in the use of pretensioning strand has been the ever increasing use of "deflected" strand. This method incorporates the economical application of strand stressed in a straight line pattern, and then brought to final design stress by deflecting the cable upwards or downwards to final position in the member. It allows the pretensioning reinforcement used to follow the moment curve of the member similar to the placement of curved or draped post-tensioning tendons.

Another effective method of producing an economical prestressed member is to utilize both of the basic methods of prestressing in a single member. Here a straight pattern of pretensioned reinforcement is used with draped post-tensioned reinforcement to give the member the exact amount of prestressing force required by the design and in the most desirable location.

Following are a few interesting comparative cost figures relating prestressed concrete with other basic structural materials:

1. A bridge crossing the Escambia River in Florida, consisting of seventy-one 36-ft spans was bid in 1954 as follows: deck construction in prestressed concrete $2.95 per sq ft, and in reinforced concrete, $3.26 per sq ft. These costs were for the deck section only.

2. Also in Florida, the Manatee River bridge containing thirty 66-ft spans (56-ft roadway) was bid at $4.55 per sq ft in prestressed concrete and $7.32 per sq ft in structural steel. These costs were for the entire structure.

3. The Great Southwest Railway constructed a prestressed concrete deck bridge between Dallas and Fort Worth, Tex., containing 2 end spans of 48 ft 6 in, and 2 intermediate spans of 68 ft 3 in for a cost of $73,658. A similar structure containing spans of 37 ft 0 in, 47 ft 8 in, and 2 at 71 ft 5 in was constructed in the same general vicinity using conventional concrete construction at a cost of $123,108. The latter bridge was actually 2 ft shorter in length than the former.

Further economies can be realized by the railroads when a greater degree of standardization of sections is attained. This has been a major factor in the economies experienced by the state road departments in their construction of vehicular bridges. The reasons are obvious. Forms for these members can be amortized by the manufacturer over a long period rather than written off completely on one project. Methods of manufac-

ture for a standard item, insofar as costs are concerned, are known to be much more economical than for special items. This is particularly true for the construction of members for buildings. Here, there is no limit to the geometric shapes and sizes a member can be produced in. These varied shapes, however, cost considerably more to produce than members which have been set up as standards, and the forms for which are reused by the various manufacturers.

A greater degree of standardization is obviously the goal of the prestressed concrete industry. It is looking forward to the day when structural prestressed concrete members can be chosen from a manual in much the same way wide-flange steel sections are chosen from the AISC Manual. A great deal has already been done toward this goal, but much more effort and cooperation between producer and consumer yet remain to attain this goal.

Mr. Ruble: Would you have any time for discussion? This is a golden opportunity to ask some questions of these three gentlemen, who are real experts in the field.

President Woolford: There must be a few questions from the audience. Does anyone want to know a little more about this prestressed concrete?

E. T. Franzen (CRI&P): Mr. President, this is directed to Mr. Wilson. Would you please explain in a little more detail the difference in shear strength between the prestressed concrete beam and the conventional reinforced concrete beam.

W. R. Wilson: There has been only one series of large scale tests on shear in prestressed concrete to date. Many more tests contemplated but, based on this one series of tests, it was found that as long as the beam isn't cracked, the shear is very much on the safe side as compared with a conventional reinforced member. The reason is that in prestressed concrete there is a very large compressive force in the bottom flange of the prestressed beams due to the high tensile force in the prestressing stands. This force causes individual particles of the beams to be compressed, and when you bring shear forces across them, increases the shear resistance. However, after the cracking load occurs, the prestressed beam begins to act more like a conventional reinforced concrete beam and then, because you have the cracks in the web, you will have a smaller part of the concrete to resist the vertical shear. However, that concrete is still in compression, so our new Committee 8 specifications call for designing the beam for shear at ultimate loads, using ultimate stresses, and it is designed as a conventional reinforced concrete beam with this ultimate load condition.

Also, the stirrups are placed accordingly, and we are very sure that when you get the working loads with the high compression throughout the beam, you are going to have plenty of excess strength in shear.

Mr. Ruble: Thank you, Mr. Wilson. Does that answer your question, Earl?

Are there any other questions, gentlemen?

F. E. Schneider (Santa Fe): I would like to ask Dr. Ekberg to explain a little more in detail what is meant by partial prestressing.

Dr. Ekberg: I wonder if the projectionist has the slide which shows an elevation drawing of a prestressed beam? Could you project that, please. Partial prestressing—Let's think in terms of the concrete. We will restrict our thinking to the concrete section at mid-stem, let's say the critical section of the beam. If the concrete is not in compression at the bottom fiber under working load, if there is some tension there under working load, then it is a partially prestressed section. The top view on the slide shows an elevation view of a beam. Let's think of it first of all as a reinforced beam, a conventionally reinforced rectangular section, under working load, and the steel, let's say,

is all in one row, about one-third of the way up from the bottom. Now, in the middle diagram we see a partial elevation, a free-body diagram of the left-hand portion of that beam. There are three forces exposed there that are holding that segment up—the C force acting on the concrete, a compressive force acting above the middle third of the section, A V force also acting on the concrete, a shear force, that is, and a T force acting on the steel. Now, the forces of C and T form a couple and the moment of that couple is, of course, equal to the bending moment at that section. You will notice that the C force is high on the section. If we think of that C force as being resisted entirely by the concrete, then it is easy to visualize that the bottom fibers would crack because of the eccentricity of that C force. It is outside of the middle third, so it must necessarily crack the concrete. The T force, on the other hand, is acting solely on the steel. The steel in this conventionally reinforced case performs two functions: it resists the T force and it also tends to distribute or minimize the cracking. These are deformed bars, supposedly, because it is conventionally reinforced. So we should think in terms of two functions there for the steel: to minimize cracking through the deformation of the bars and to resist that T force.

Now, in the lower view we see the same beam under the same load if it were prestressed. The moment, the product of C, or T times this resistance, is the same as the moment in the middle view. On the other hand, the C and T forces must necessarily be larger and, of course, they can be larger, because we are using higher strength steel and higher strength concrete as well.

Now, you will notice that that C force is within the middle third of the rectangular section, so it is not going to cause cracking under working load. The steel here simply resists the T force. It is not deformed steel. Cracking is not a consideration here. It is simply a matter of resisting that T force. On the other hand, if we were to partially prestress, we would allow tension in that bottom fibre of concrete and at the same time the force, C, would be higher up on the section; it would be outside of the middle third in that case. So we would have to supplement that prestressing steel with conventional unprestressed reinforcing to minimize any cracking which might occur. I hope that explains that point. The advantage, you see, would be to spread the C and T forces so you could resist a larger moment.

Mr. Ruble: Are there any other questions?

President Woolford: I think we had better go on to the next committee report, because we are going to have to get through here by noon. If you have any further questions, this committee would be glad to receive them in writing and answer them for you.

Chairman Musser: Thank you very much, gentlemen, for your very interesting and educational presentation.

President Woolford: I regret that we couldn't carry on and answer more questions, but we do have two more committees to report this morning. It is very evident, Mr. Musser, that in your first year as chairman of Committee 30, you are keeping the work of this committee moving ahead on a number of very important subjects. It is imperative, of course, that your committee do this, because our other structural committees look to your committee for guidance with respect to the matters of impact and bridge stresses.

Your Symposium, jointly with Committee 8, on the Application of Prestressed Concrete to Railway Structures, has been most interesting and enlightening and we thank you, Mr. Ruble, Dr. Ekberg, Mr. Nicholson and Mr. Wilson for your contributions.

We are sorry that Mr. Gillan couldn't be with us today. Possibly he thought that his talk would be in connection with prestressed ties later in the day.

Mr. Musser, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Iron and Steel Structures

[For report see pp. 557-583.]

[President Woolford presiding.]

President Woolford: Moving along, gentlemen, we now come to the report of another of our very important structural committees, Committee 15—Iron and Steel Structures. Will the members of Committee 15 please come to the speaker's table as quickly as possible.

The chairman of this committee is D. V. Messman, engineer of bridges, Central Lines, Southern Railway System. Mr. Messman, I would like to ask you if you can to try to squeeze the 40 min allowed you into 30, so we may close up by noon at the latest so we can proceed to our Annual Luncheon on time.

And Chairman Johnson of Committee 29, I regret to have to tell you, but we will have to postpone your report until immediately after the Luncheon.

Mr. Messman, will you please take over.

Chairman D. V. Messman: Mr. President, since last year's convention, your Committee on Iron and Steel Structures has lost two of its valued members, Professor T. C. Shedd of the University of Illinois and L. L. Shirey, former bridge engineer of the C&O at Richmond, Va. Their memoirs are included in Bulletin 555, along with the regular annual report of Committee 15.

In our report I call particular attention to new material on perforated cover plates and floorbeam hangers, and to extensively revised material on electrical requirements for movable railway bridges, these three items resulting from considerable effort on the part of our subcommittees. We hope that all interested Association members will carefully review these parts of our report and give us the benefit of their comments, so that this material can be submitted for adoption next year.

Assignment 1—Revision of Manual.

Chairman Messman: Our report includes recommendations for revision and reapproval of Manual material, all having received the required affirmative vote by letter ballot of the committee.

Mr. President, I move that the Specifications for Steel Railway Bridges, Manual pages 15–1–1 to 15–1–42, incl., be reapproved with the revisions detailed on pages 560 and 561 of Bulletin 555, which concern tensile test requirements for A–7 steel and redefinition of terms in the secant column formula; also that the Instructions for the Maintenance Inspection of Steel Bridges, Manual pages 15–6–9 to 15–6–14, incl., and the data on Large Rivets, Manual pages 15–M–21 to 15–M–26, incl., be reapproved without change.

[The motion was duly seconded, was put to a vote, and carried.]

Chairman Messman: Before proceeding with our special feature, I invite comments or questions from the floor concerning our report. If there are no comments, we will continue.

Our special feature consists of two separate addresses concerning the truss bridge research project which has been under way for some time at Northwestern University.

Gerald C. Ward, civil engineering administrative director of the project, will first discuss the construction and loading of this test bridge. I am pleased to present Mr. Ward to you.

Construction and Loading of Half-Scale Test Bridge at Northwestern University

By Gerald C. Ward

Civil Engineering Administrative Director, Truss Bridge Research Project

What It Is

The Truss Bridge Research Project consists basically of a 100-ft, half-scale steel truss bridge (Fig. 1) resting upon a massive reinforced-concrete test bed, with an arrangement for placing loads of varying magnitudes and patterns upon the structure, together with the instrumentation necessary to measure and record the effects.

The Project had its origin as long ago as 1920, when Professor Parcel, then at the University of Minnesota, is said to have suggested that a good way to find out how various members of a structure act under destructive loads might be to build a bridge in which selected members could be destroyed under the end conditions which are encountered in service.

This would overcome the obvious disadvantages of testing existing highway and railway structures, which must not be damaged during the tests, or of testing built-up structural members in laboratory testing machines wherein the end conditions cannot be completely duplicated.

Although many people agreed that this was a good idea, nothing came of it until 1952, when Committee 15 of the AREA decided to do something about it. During the ensuing four years, the bridge was designed by Prof. L. T. Wyly, the foundations were begun in April of 1957, the bridge was erected in November of that year, and a building to house the Project was completed in August 1959. In the Spring of 1959 an hydraulic system for loading the bridge was installed, and the first loads were imposed on the structure in June. Since that time a series of operational and calibration tests have been run, a research program established, and initial investigations of end-post failure have taken place, under the supervision of John F. Ely, acting director of the Project.

The test bridge is a half-linear-scale model of a 200-ft, 8-panel, Warren type, railway bridge. A departure from normal bridge construction has been made, wherein the two trusses are not identical—the east truss contains members with the angles turned inward, and with perforated cover plates representing present-day bridge construction, while the west truss is built in the traditional manner, with angles turned out and the members laced, representing older types of existing bridges.

Each of the trusses is built of medium-manganese high-strength steel, except for the member being tested, which is composed of ASTM A-7 carbon steel. The difference in yield points of these two materials permits the test member to be destroyed without serious damage to the remainder of the structure.

All joints being fastened with high-strength bolts, it is possible then to remove the destroyed member and replace it with another of improved design. A succession of members, of different design, can thus be tested in this particular position. When the desired information about this portion of the structure has been obtained, the test member will be replaced by a medium manganese member, and similar series of tests will be conducted on other members. It is contemplated that this program of research will require several

Fig. 1—Completed bridge prior to erection of enclosing building.

years, and it is expected, among other things, to lead to improved or extended column theory.

The Project is conducted as an activity of the Civil Engineering Department of the Northwestern Technological Institute. It is sponsored financially by the Association of American Railroads, the American Institute of Steel Construction, the U. S. Bureau of Public Roads, the Corps of Engineers of the U. S. Army, and by the University. A large number of commercial, engineering and industrial organizations and individuals have made substantial contributions of materials and services.

Total investment in the Project to date is something more than a half million dollars—a measure of the faith and confidence of the sponsors and contributors in the merits of the Project and the results which may be expected from it.

How It Works

The principal operations are the loading of the bridge, the observation and recording of data, the processing of data, theoretical studies arising therefrom, publication of results, and the planning of further research activities.

The observation and recording of data will be accomplished by means of systems of electrical, mechanical and optical instrumentation, and by recording apparatus which forms a part of the hydraulic loading system.

The loading of the bridge will be done hydraulically—the means for doing so being the principal subject of this paper.

Fig. 2—Arrangement of hydraulic jacks for applying controlled loads.

Loading the Bridge (Fig. 2)

Loads are applied to the structure by fourteen 150-ton hydraulic jacks, located in pairs, bearing upon the stringers of the bridge at their connections with the floorbeams. They are energized by centrally located pumps, regulated from one centrol control panel. The loads are closely controlled and accurately measured by automatic equipment.

In order best to simulate a stationary load, such as that of a locomotive standing on the bridge, the loading system must be able to follow closely any deflection of the structure and maintain a constant load upon it. While this requirement may appear obvious, it is not met by all types of hydraulic equipment. The need for this capability can best be appreciated by considering the action of the materials of the bridge, under load.

At the time the steel in any member reaches its upper yield point, it will begin to deform without increase in load, and the phenomenon of the "dip" in the stress-strain curve will occur. When this happens in a laboratory testing machine, the stress-strain curve actually indicates a decrease in the load upon the material unless great care is taken in the operation of the machine, and an additional volume of fluid, at the attained pressure, is rapidly supplied to the hydraulic cylinder. If this is done, the dip in the stress-strain curve can be avoided, and the load upon the specimen will remain constant until strain-hardening has improved its load-carrying capacity, and a higher load can be imposed. Meanwhile, internal work will have occurred within the specimen in the form of rapid deflection.

In the case of a test member of the bridge, yielding may begin at one or more points, spreading rapidly to adjacent parts, until some portion of the length of the

member is involved. The precise course of this action being unpredictable, and the time and place of buckling of the member not known in advance, the assumption has been made that the most extreme condition will prevail—wherein the material throughout the entire length of the test member is simultaneously in an inelastic state, the member is deflecting axially without increase in load, and buckling has not yet taken place. While this appears to be a well-nigh impossible situation, it is difficult to say just how closely the test member may approach it at any particular time, and just where the common-sense line should be drawn when it comes to designing the hydraulic loading system.

This means that, when any part of the structure begins to yield, the jacks must be supplied quickly with added volumes of hydraulic fluid, at the attained pressure, needed to keep their pistons bearing down on the bridge during the deflection, and providing a constant load upon it. Pumps, valves, piping, control apparatus and jacks were selected with this in mind.

Of course, when the materials of the bridge are still in the elastic state, and no buckling has commenced, this problem does not exist—the loading consists simply of maintaining a constant hydraulic pressure in the jacks, with very little movement of fluid in the system. This type of loading presents relatively few problems.

The Hydraulic System

To make a long story short, the unusual requirements for loading the bridge were met by a system, donated by the Bethlehem Steel Company, developing maximum operating pressure of 6000 psi, to achieve 150 tons per jack, or a total load of 4,200,000 lb.

It was necessary to provide for various loading patterns—to simulate, for instance, a heavily loaded train on one track and a lightly loaded one on the other; or a locomotive at one end of the bridge, followed by a string of empty flat cars. This was accomplished by running two complete hydraulic circuits around the entire structure, terminating in headers at each jacking point. Individual jacks are connected to the appropriate header of either of the circuits with high-pressure hoses which are fitted with quick-disconnect couplings. Thus the jacks can be assorted between the two circuits, all connected to one, or not connected at all. It being possible to maintain either circuit at any pressure between 0 and 6000 psi, it will be seen that a very wide range of loading patterns is possible.

The two circuits are each powered by an air-driven hydraulic pump, consisting basically of a 10-in air cylinder and a 1⅛-in hydraulic plunger, mounted on the same piston rod. For approximately 82 psi air input, the pump delivers 6000 psi. Lesser hydraulic pressures are obtained by introducing an air-pressure regulator into each of the lines which supply air to the pumps.

Air pressure is supplied by a series of three compressors, so arranged that they can be put on stream as required. A very large air storage capacity has been provided, to meet conditions when the bridge is deflecting rapidly, and large quantities of hydraulic fluid, under pressure, are required to keep the jack pistons following the deflection and the load constant.

Controlling the Load

Inasmuch as it was desired, at the outset, to maintain the load to an accuracy of 1 percent, it was early realized that hand regulation would not do the job. Therefore, an over-riding system of automatic controls was superimposed upon each hydraulic circuit.

The control system consists basically of two pneumatically operated control valves in each of the high-pressure jacking circuits. One of these admits fluid into the circuit,

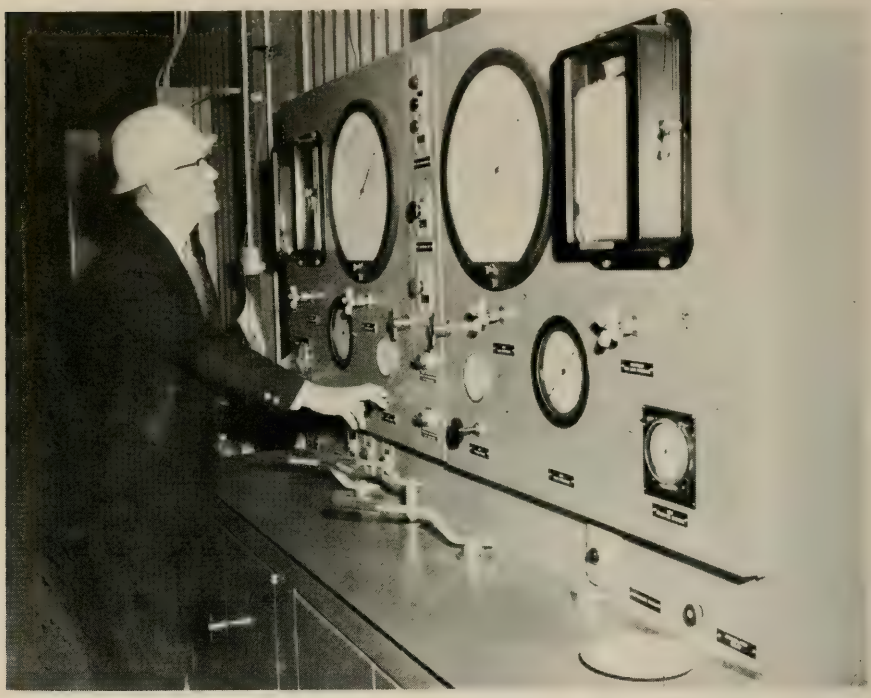


Fig. 3—Central panel for controlling hydraulic system.

the other relieves pressure. They assume various positions, between fully open or completely closed, in accordance with a pneumatic signal they receive from an automatic controller.

The controller can be set to maintain a desired pressure in the jacking circuit. It receives information from a sensing device in the jacking circuit as to the pressure being supplied to the jacks. It compares this information with the desired pressure, and causes the control valves to open or close so as to correct any difference. A variation of as little as 0.1 percent of system pressure will cause this instrument to function.

This ingenious and highly precise instrument, along with other operating controls and load recording apparatus, is mounted on a central control panel (Fig. 3) located alongside the bridge structure, from which all loading operations are carried on.

The net result is that loads upon the bridge can be imposed, maintained, and controlled to a precision of 0.1 percent—10 times better than was originally hoped for, and better than most laboratory machines—and it was done entirely with commercial components, bought "off the shelf" and integrated into a smoothly functioning loading system. [Applause]

Chairman Messman: Thank you, Mr. Ward.

We will now hear from John F. Ely, acting director of the Project, who will describe and discuss the program as a whole and the current results.

Current Results and Research Program of the Truss Bridge Research Project at Northwestern University

By John F. Ely
Acting Director, Truss Bridge Research Project

Research Program

The research program (Slide 1) as established to date has been divided into three phases designated as Test Programs 1, 2, and 3.

Test Program 1 has been completed, and a preliminary report has been published. The purpose of this program was two-fold: (1) to perform preliminary, investigatory tests to establish successful methods of operation for the tests to follow, and (2) to perform certain basic investigations which were important in themselves. There were three series of tests conducted in this program:

1. Influence lines for direct stress determined experimentally.
2. Stresses and forces under one-track eccentric loads.
3. Stresses and forces under full design load and the establishment of a loading and testing procedure for the destructive test of the endposts.

The purpose of Test Program 2 is to establish a method of estimating the ultimate load of damaged endposts. This problem arises when a train load has shifted and struck and bent an endpost. This program has been divided into 2 series (Slide 2):

1. Destruction test of straight endposts.
2. Destruction test of bent endposts.

Determination of the effects of the floor system in truss action and of the stresses introduced by the erection of the floor system are the objectives of Test Program 3. This program has been divided into three series (Slide 3):

1. Stresses in loaded bridge with floor system removed.
2. Stresses in loaded bridge with floor system in place.
3. Stresses introduced during erection as a result of clearances between the stringer and the floorbeams.

Tests that have been run so far have themselves suggested many new areas of investigation. Definite plans have not been made beyond those mentioned above, because analysis of the data from these tests may suggest a new, more interesting, and more rewarding group of tests. In all past tests slip gage readings at the joints were taken, and will be taken on all future tests.

Current Results

The general conclusions and a general discussion will now be given for each of the completed tests.

Influence Line Tests:

The influence line tests indicated that the forces computed on the basis of the simple truss assumption are very close to those found experimentally. The only exception to this occurs in the lower chord and diagonal members, where the measured stresses were lower than those computed. The reason for the lower measured stresses is, of course, that the floor system acts as part of the truss's lower chord. The precise effects of this action will be investigated further in Test Program 3. To summarize, the conclusions reached on Test Program 3 were:

TEST PROGRAM 1

PRELIMINARY, INVESTIGATORY TESTS

SERIES I EXPERIMENTAL INFLUENCE LINES

SERIES II ONE TRACK LOADED

SERIES III DRY RUN AT DESIGN LOAD FOR DESTRUCTIVE TEST OF ENDPOST

Slide 1.

TEST PROGRAM 2

DAMAGED ENDPOST TESTS

SERIES I DESTRUCTIVE TEST OF STRAIGHT ENDPOST

SERIES II DESTRUCTIVE TESTS OF BENT ENDPOSTS

Slide 2.

TEST PROGRAM 3

FLOORSYSTEM PARTICIPATION

SERIES I LOADED BRIDGE - FLOORSYSTEM IN PLACE

SERIES II LOADED BRIDGE - FLOORSYSTEM REMOVED

SERIES III ERECTION STRESSES CAUSED BY CLEARANCE BETWEEN STRINGERS AND FLOORBEAMS

Slide 3.

1. The forces computed for the upper chord, using the simple truss assumption, are within 5 percent of those found experimentally.
2. The measured force in the lower chord and diagonals was between 62 and 76 percent of the computed stresses.

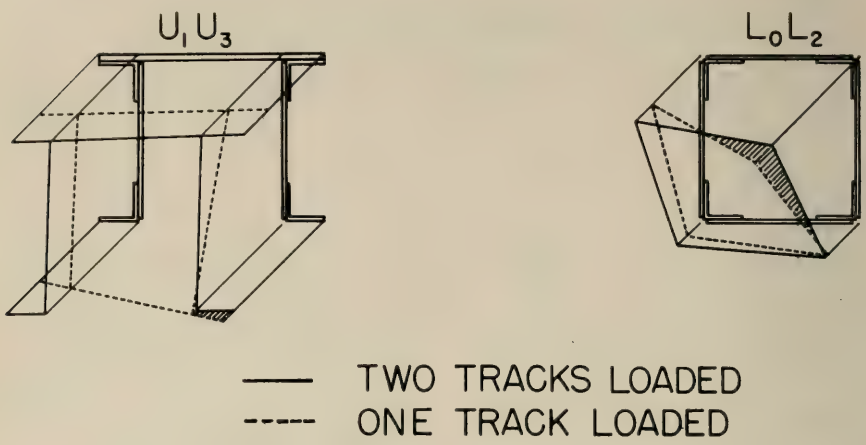
Stresses and Forces Under One Track Loaded:

There were two purposes of this series: (1) to determine the distribution of forces to the two trusses with one track loaded, and (2) to determine the distribution of stresses within the members of each truss with one track loaded. The force in a given member with one track loaded was between 60 and 78 percent of the force with two tracks loaded. This indicates, as to be expected, that the forces are less when only one track is loaded; however, the secondary stresses that occur under the eccentric loading must also be considered. In several sections the stresses were higher with one track loaded than with two tracks loaded. The stresses for each loading are shown in Slide 4.

Stresses and Forces Under Full Design Load:

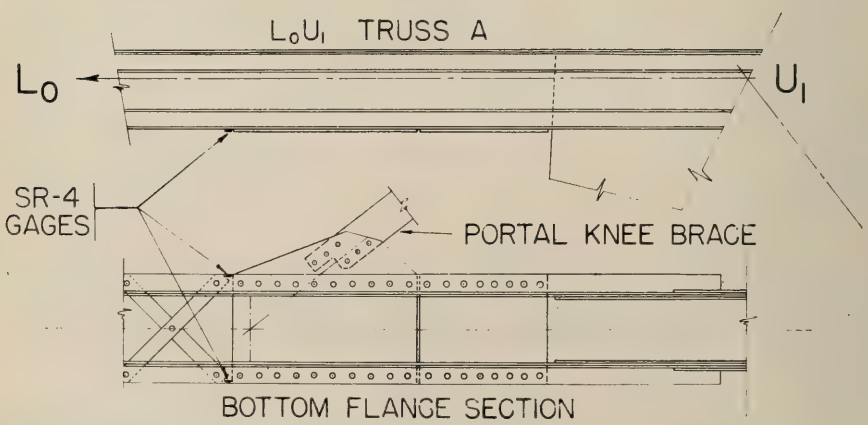
This test served as a "dry run" for the destructive test of the endposts which was to follow. During this test, the loading system, the required instrumentation, and the fact that it would be possible to fail the endposts without damaging the high-strength members of the bridge were established. In addition several results were discovered that were interesting in themselves.

1. (Slide 5) The stay plates on the endpost of Truss A appeared to cause stress concentrations in the outstanding legs of the angles outside the stay-plate connection. The concentration amounted to 2.0 times the average measured stress in the member.
2. The stresses at the L_0 joint were subject to considerable stress concentrations, and (excluding the concentrations caused by the ovaloid perforations) the stress was 1.7 times the average measured stress in the member.



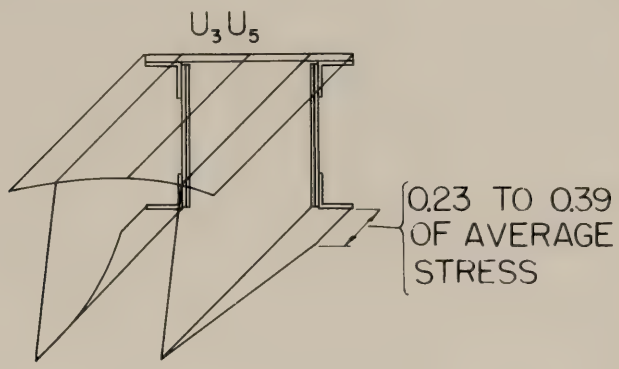
COMPARISON OF STRESSES FOR ONE AND TWO TRACKS LOADED

Slide 4.



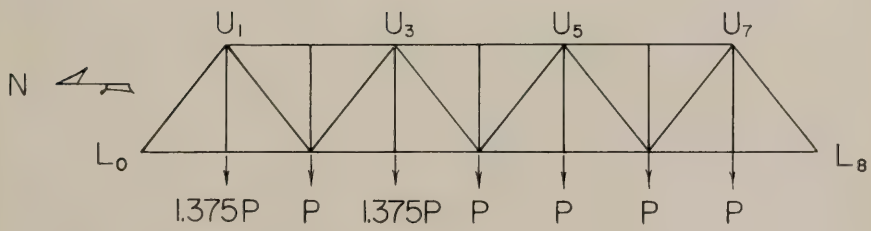
GAGES INDICATING STRESS CONCENTRATIONS

Slide 5.



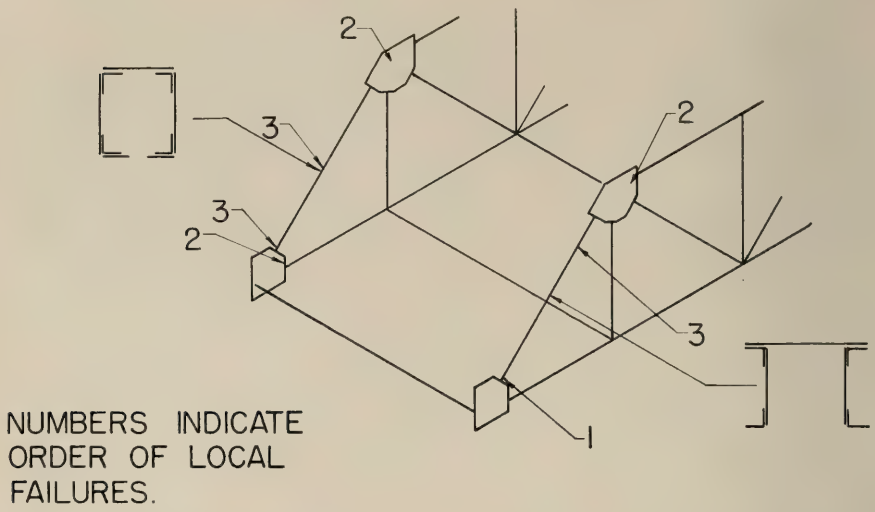
LOW STRESSES IN OUTSTANDING LEGS OF ANGLES

Slide 6.



LOADING

Slide 7.



CHRONOLOGICAL DEVELOPMENT
OF LOCAL FAILURES

Slide 8.

3. (Slide 6) The outstanding legs of the lower angles in U_3U_5 did not take their full share of the load, and the stresses in the toes of these angles was 0.23 to 0.39 of the average measured stress in the member.
4. The stress concentration at the edges of the ovaloid perforations on Truss B was tabulated, and the overall average value was 1.67.

Destructive Test of Straight Endposts:

This test was conducted on November 4, 1959, and has received considerable publicity since then, although no data have been released except for the failure load. Much of the data has been reduced, but not all of it has yet been "analyzed." The term "analyzed" is used here to mean "an endeavor to make the data meaningful." Some tentative conclusions have been reached already, and checks to determine the validity of these conclusions are being performed. Before discussing the conclusions, the loading and instrumentation will be briefly explained.

Loading:

The loading found to be satisfactory is shown in Slide 7. This corresponds to two trains, both traveling north, and positioned for maximum stress in the endpost. Naturally, the loading could not be "exact", since there are only two different loads other than zero that can be supplied by the hydraulic system. The load was idealized, keeping the stress in the endpost the same.

	TRUSS A	TRUSS B
MEASURED LIVE LOAD	35.2	32.1
COMPUTED LIVE LOAD	33.8	32.1
COMPUTED DEAD LOAD	4.85	4.60
TOTAL MEASURED	40.0	36.7
TOTAL COMPUTED	38.6	36.7
YIELD POINT	40.6	41.3
ULTIMATE/YIELD POINT	0.98	0.89

STRESSES IN L_0U_1 AT ULTIMATE LOAD

Slide 9.

Instrumentation:

Three hundred SR-4 strain gages were used to measure the strains in the members. The deformations, both linear and angular, were measured by means of level readings on scales that were attached to thin, hanging, weighted wires. Although rather primitive equipment was used, these readings produced useful and fairly accurate data. It is hoped that the new, very precise, optical system which will greatly improve the accuracy of displacement data, will be in place for the next test.

Conclusions:

It is to be understood that the conclusions given here are, for the most part, tentative and are based on a partial analysis of the data.

1. The ultimate load was 2.3 times design load; where the design load includes live load, dead load and impact.
2. Both of the endposts failed! Proof of this is demonstrated by (1) the bridge continued to deflect under a constant load, and (2) the fact that when a limit switch was tripped, the load began to decrease gradually, and under this decreasing load the measured strains in both endposts continued to increase. In addition, several plots made during the test showed that the load vs. deformation curve was flat at the ultimate load.
3. SR-4 strain gage readings indicated that at several locations there occurred either a local buckle or a local bend in one of the elements of the main material or gusset plate. A chronological development of these has been established and is shown in the sketches of the bridge in Slide 8.
4. It appears that the failure of the endposts was caused or precipitated by a failure at the L_0 joint. It is interesting to note that this type of failure could not have been realistically achieved in a testing machine, which fact confirms the foresight of Prof. Parcel in his original realization of the need for a model test bridge.
5. The stresses at failure are shown in Slide 9 for each of the endposts. The calculated stress is again that stress computed using the simple truss assumption.
6. It has been fairly well established by many tests performed in testing machines that the buckling or ultimate load of a column with flat or pinned ends and with an l/r of 57 is from 0.85 to 1.00 of the yield point of the material. In this case there were no such end conditions, and the buckling did not occur in a plane of symmetry. It would be expected, then, that the buckling load

would be considerably less than that previously established. Also the failure was begun in the joints, which again lower the column's ultimate load. Further, we have the thought that the transverse shear introduced by the end moments would considerably lower the ultimate load and produce sudden collapse, especially of an ovaloid perforated column. The only tendency to increase the column's ultimate load is the reverse curvature caused by end moments. The ultimate load (0.98 and 0.89 of σ_{yp}), however, was in the range as that established by laboratory tests, and certainly no sudden collapse occurred.

Future Tentative Plans

Damaged Endposts Tests:

The objective of the damaged endpost tests is to establish a means of quickly estimating the capacity of damaged endposts. This program of investigation divides itself into two separate phases: (1) experimentally finding the capacity of damaged endposts under controlled conditions, and (2) predicting the capacity of damaged endposts in the field based on these experiments.

A proposal as to how these tests should be conducted has been sent to the Advisory Committee, and a meeting of this committee on March 24, 1960, will finalize these procedures. We hope to complete the testing on the bent endposts this coming fall.

Test Program 3

Investigation of Floor System:

The objectives of this test program are:

1. To determine the participation of the floor system in truss action.
2. To determine the erection stresses, which are caused by the clearance between the stringer and the floorbeam.

This program will be carried out immediately after the testing of the damaged endposts.

Resumé

We believe that one fact has now definitely been established. We now have a facility to check new design concepts, to verify new analytical theories on a real bridge, not only in the elastic range, but up to and including ultimate loads. [Applause]

Chairman Messman: Mr. President, this concludes our report.

President Woolford: Thank you, Mr. Messman. I am sorry I had to cut you short so we can't ask for discussion from the floor. We have certain guests here for luncheon and we must push along. We will have to defer the report of the next committee until the afternoon session.

Thank you again, Mr. Messman, and thank you, Mr. Ward and Mr. Ely. We are all glad to see the Model Truss Bridge Project at last really moving ahead and in capable hands. We appreciate your informative description of the project, the purposes thereof, and the results already accomplished and in prospect.

Mr. Messman, your committee is now excused with the thanks of the Association. [Applause]

This completes our morning session. Before we recess the meeting for our Annual Luncheon, which is about to be held in the Grand Ballroom, I would like to remind

you that our afternoon session will convene in this room at 2:15 with another long program of reports and special features ahead. Early on our program this afternoon we will hear an address from Bertram D. Tallamy, federal highway administrator, Bureau of Public Roads, and I hope that all of you will be present in order to give him a good audience and to hear his message, which I can assure you will be most informative.

The meeting is now recessed for the Annual Luncheon in the Grand Ballroom. Will you please proceed to the Grand Ballroom and take your seats at your designated tables. Again I want to remind you, please be back here to reconvene this meeting at 2:15 this afternoon.

[The meeting recessed at 12 o'clock.]

Annual Luncheon

Grand Ballroom—12 Noon
Tuesday, March 15, 1960

[The annual luncheon was held in the Grand Ballroom with a background of organ music. At the main speaker's table were seated executives of various railroads, officers of the AREA and AAR, and several special guests. At a long table immediately in front of the main speaker's table were seated the chairmen of the Association's 23 standing and special committees.

After the luncheon those assembled sang the national anthem, following which President Woolford introduced those at the speaker's table and then those at the chairmen's table. He also introduced the incoming committee chairmen, who were given gavels. Then, after announcing the results of the election of officers (see teller's report appearing on page 982), President Woolford introduced the speaker at the luncheon—Mr. Frederic B. Whitman, president, Western Pacific Railroad, with the following remarks]:

President Woolford: Gentlemen, with these important preliminaries out of the way, I now come to the piece de resistance of this Luncheon program—the introduction of our speaker. If in my introduction of our speaker, I appear a bit over-zealous concerning him, I hope you will pardon me, because having been closely associated with him since joining the Western Pacific some 11 years ago, and in a position to observe constantly his boundless energy and ability, it is difficult for me to be otherwise.

Our speaker is a native of Cambridge, Mass. He attended Harvard University, from which he was graduated with a Bachelor of Arts Degree in 1919. Subsequently, in 1921, he was graduated from the School of Business Administration at Harvard with high honors.

He actually entered railroad service in the summer of 1919 as a locomotive fireman and machinist helper on the Fort Worth & Denver City, transferring to the Chicago, Burlington & Quincy Railroad in 1921, where he served in various departments until 1939, when he was promoted to division superintendent at St. Joseph, Mo. From 1945 to 1948 he served successively as superintendent of the McCook Division, and general superintendent of the Western District, at Lincoln, Nebr., where he was located when, on October 1, 1948, he was called away from the Burlington to become executive vice president and director of the Western Pacific Railroad, with headquarters at San Francisco. On July 1, 1949, he was elected president and director of the Western Pacific and of its various subsidiaries and affiliates—the position he now holds.

Since becoming president of the Western Pacific—through his energy, ability and business acumen, combined with his pleasing personality—he has raised the stature and reputation of our railroad to that of one of the finest and most progressive in the country.

All of us on the Western Pacific have been challenged and stimulated by his leadership, and have enjoyed working with him. I now want to present this man to you—one of the foremost railroad presidents of the country—who will address us on "The Challenge for Progress"—Mr. Frederic B. Whitman, president of the Western Pacific Railroad. Mr. Whitman.

The Challenge For Progress

By Frederic B. Whitman

President, Western Pacific Railroad

Mr. Chairman, distinguished Guests, ladies and gentlemen:

Some few months ago when Frank Woolford, your president and our chief engineer, asked me if I would talk to you today I told him I would feel honored to have the privilege of presenting a few thoughts for your consideration, which I hoped would be helpful in the very important contribution that you and your organization can make to the industry. I selected the subject "The Challenge for Progress" because I firmly believe that we in the railroad business must constantly look ahead to the future. That is not to say that we shouldn't look back occasionally, but only for the purpose of determining how we might have done things better so that we may do them better in the years to come

I believe that the challenge for progress in the railroad industry is greater today than it has ever been in the past, and that the future opportunities for success of the railroads appear more favorable than they have been in the last 30 years. I also feel that we are on the threshold of being better able to take advantage of the opportunities confronting us than ever before. One of the reasons that I feel this way is that the attitude of many of the modern-day railroad managers has never been more forward looking than it is today. I would not wish to disparage the efforts that have been made in the past, and certainly the American Railway Engineering Association has made most substantial contributions to railroad progress, but there are so many opportunities for further progress now which I feel we are so much better equipped to meet that I can not help but be optimistic. I would like to offer you some of my views as to various philosophies of management which I hope may make a contribution towards meeting the challenge.

Before I outline some of these philosophies of management that seem important to me, let us look at a few facts.

In 1930 railroads carried 74 percent of all intercity freight ton-miles. Trucks accounted for only 4 percent. The latest available figures show that the railroads' share has dropped to 45 percent while the trucks are handling about 21 percent. Nevertheless, total railroad freight has not declined. I know the reasons are obvious to you—namely, that the population and the gross national product have increased substantially so that a smaller share of a larger potential has kept us somewhere near even.

Now the population and the gross national product are both going to continue up. But I don't believe our share is going to continue down. I think we are going to have a bigger share of a bigger total.

Saturation of highways (and airways) will produce an overflow of traffic to the railroads, and this overflow can be expected to increase as congestion of other transportation facilities become more acute. The rapid growth of piggyback is a manifestation of this condition.

A more tangible reason for optimism regarding the railroad share lies in the passage of the Transportation Act of 1958 which, with all its faults and omissions, at least marked the end of 18 years of public apathy toward railroad problems and provides a firm foundation on which to press for further improved legislation and relief from over regulation.

Now may I make some suggestions as to the various aspects of management philosophy that I feel will enable us to meet the challenge.

The first of these is my firm belief that while our efforts to reduce costs and operate more efficiently and economically must not only not be relaxed but must be intensified, the primary objective of our efforts must be towards improving and developing a managerial philosophy of the "hard sell" designed to greatly increase our freight sales. This is in contrast to the past in that during that period efforts of management had been largely directed towards trying to develop ways and means of operating more efficiently and economically rather than toward developing and increasing our ability to secure for ourselves a greater proportion of total transportation market. I presume that the reason for the direction of our past efforts was that many managers felt that there was little that railroads could do towards adjusting prices and service because under regulation we did not have the freedom to adjust our prices, and many felt that service on one railroad was just about comparable to that on any other. However, our competitors, primarily those in the highway motor truck business, have shown us, much to our discomfiture, that there are myriad ways and means of adjusting prices and improving service with the result that we have lost ground not only in preserving our existing share of the market, but also in improving our share of the market. Thus, if we are going to correct this condition we must adopt a philosophy throughout all departments of our organizations directed primarily toward improved pricing and improved service. In my opinion, if we thoroughly embrace an aggressive attitude aimed primarily at better marketing and more skillful selling, we as managers and sub-managers have the ability and skills to substantially increase the volume of traffic we are handling.

As to pricing, while the situation is presently not entirely clear because the ICC has so far refused to promulgate a general rule concerning railroads' efforts to implement the pricing philosophy outlined in the Transportation Act of 1958, several of the ICC's more recent decisions do indicate that they have paid some heed to that philosophy in that they have approved a number of requests for price changes which appear to be most significant. I predict that as time goes on, further ICC decisions will indicate that we have reached the turning point in achieving the greater freedom in pricing which is needed to enable the railroads to regain much business which has been lost to other forms of transportation. In this connection I would point out the need for railroad pricing departments, aided by the efforts of railroad accounting departments, to develop superior cost data than that which has been used in the past to justify requests for rate changes. I am sure that with the increased use of data processing which can provide a great deal more information more quickly, our cost data should improve substantially. To the extent that it is practicable, our data should be based on approved ICC formulas with selected appropriate modifications made possible by the much greater use of data-processing equipment.

Again, through the aid of data-processing equipment and through developing greater skills in analyzing the economic effect of price changes on the volume of our traffic, we should be able to do a much better job of calculating the net income which may be

derived from various potential movements. In this way we may offer incentive rates, volume rates, and perhaps even agreed charges which will attract traffic which will bring us the maximum net.

Since in many instances rate adjustments to produce maximum net will depend on reducing costs, it is important that we continue to find ways and means of reducing costs. Reductions in cost are always made more difficult by the constantly recurring wage increase demands with which the railroads have been and probably will continue to be faced, but fortunately there are still many opportunities for effecting reductions available to us if we will but exercise the necessary resourcefulness and ingenuity to find them.

At this time I pay tribute to the work of your organization over the years along the lines of research which has done much to develop better ways and means of building and maintaining track and structures more economically. In my opinion, the work which the AREA has done in the way of research is probably more comprehensive than that of any of the other railroad professional associations. However, there must be much more of research and its quality must be better still to search out every possible way in which costs may be reduced. All of you are familiar with the revolution which is now taking place in the maintenance of track structures by the introduction of labor-saving devices. Much of the research which has gone into the development of these machines has been contributed by the manufacturers rather than by the railroads themselves. This is a tribute to the imagination of the manufacturer but I feel that we on the railroads should be doing just as much or more to make a like contribution towards developing improved machines, devices and methods.

This leads me to suggest another philosophy of management that I believe is not only important in the maintenance of track and structures but also throughout our entire scope of railroad operations.

The philosophy of which I speak is that of applying the process of careful analysis of all the factors involved in any problem and an even more careful examination of what can be accomplished to change those factors. A friend of mine, now deceased, once described the efforts of railroad managers as "A brilliant example of magnificent improvisation." His comment was directed to the fact that so many of us in the railroad business spent so much time in "putting out fires" that we overlooked the more important need to develop better methods of "fire prevention." I believe that there is much to be done in developing better methods of "fire prevention." In other words, our efforts should be directed toward finding long-range solutions of problems and development of programs to prevent those problems from recurring rather than devoting as much effort as we have toward just meeting emergencies. As present-day efforts to recruit better technically trained people into the industry are vigorously pursued, the philosophy of the more effective use of analytical processes for long-term solutions will spread throughout all departments so that in the future we will do a much better job of research and planning. In fact, if we are going to do the job of reducing costs that is necessary, widespread adoption of this philosophy is essential.

This philosophy of the analytical process is the basis for the studies which are now being made on some railroads by the trained engineers who are investigating the possibility of introducing data-processing equipment in individual companies. In the instance of the Western Pacific the introduction of this analytical process to various phases of clerical work has resulted in our being able to make rather substantial cuts in clerical forces. The task force which we set up was composed of some of our own people who had been given very thorough training under the direction of engineers furnished by the

different manufacturers of data-processing equipment. They became skilled in the analysis of the work of each clerical job not only to study and record the content of the work but also record the time each operation required. After this study was made the data were carefully analyzed primarily for the purpose of determining what changes, if any, might be made in the data which were to be used but also for the purpose of determining whether some of the intermediate steps in the preparation of these data might be eliminated. Likewise, it was found that by combining the work on certain jobs with the work on other jobs, peaks and valleys of temporary periods of idleness might be eliminated. The net result, as I have said, was the elimination of a substantial number of jobs. I am sure that as our task force progresses its work throughout the various other departments many more similar opportunities will be found which will enable still greater reductions in force.

Another philosophy of management which I feel deserves far greater emphasis is the development of skill in encouraging managers and employees alike to develop new and original ideas. People, generally speaking, are creatures of habit. As creatures of habit, all of us tend to be somewhat reluctant to accept change and new ideas. However, if we are going to meet the challenge confronting us, the encouragement to develop this skill on the part of all of our people to develop new ideas and to accept changes more readily becomes vitally important.

One of the means whereby the development of new ideas and the acceptance of change can be encouraged lies in greater delegation of responsibility. Greater delegation of responsibility by a superior also implies better acceptance of responsibility by subordinates. In my experience of almost 40 years in the railroad business it seems to me that many times when a subordinate is promoted to a higher managerial job the individual tends to take with him to the higher job the duties and responsibilities he formerly had on the lesser important job. Again, I think the matter of habit has something to do with this in that the individual knew how to do his former job well but when he moved to a position of higher responsibility he tended to fill his time with the duties and responsibilities of his former job because he did know how to do them well, and he wasn't sure as to how to carry out the duties and responsibilities of the higher job. The net result was that whoever succeeded to his former position as a subordinate was directed far more from above than was necessary or desirable.

Probably the reason for this condition is our failure on the part of management to realize the need for more and better special training of men moving up so that those promoted fully understand the duties and responsibilities of their new job. Thus, there does exist a great need for making sure that suitable programs of training and development are evolved at all levels of management to make sure not only that men properly delegate their responsibility but likewise that the responsibility is properly accepted by the subordinate.

If such management development training programs are properly conceived and executed I am sure that it will do much towards encouraging the development of new ideas and approaches because when a man fully understands that he does have responsibility and authority for carrying out his particular duties rather than being told by higher authority what to do, in most instances he will respond. In comparing the railroad business with outside industry I believe that there is much more we can do to encourage this philosophy of management. To the extent that we do we will encourage a much greater initiative in the use of new ideas and approaches than we have had in the past.

Another philosophy of management I could mention which involves a much larger field is that of educating our managers to use better techniques in handling human rela-

tions. Much has been said and written about the importance of improving skill in handling human relations in industry, some of which is based on sound philosophy and some of which is not. However, we are all aware that even though we may equip ourselves with the best machines that can be found, unless we have the wholehearted cooperation and interest of the people who are going to use those machines, our results will not be as satisfactory as we should expect. Thus, the whole subject of better handling of human relations does become what is perhaps to me the most important particular factor in the operation of a railroad, or for that matter of any business. It is in this field that I believe your Association can do much more research than has been done in the past. From my observation, many engineers tend to be more interested in machines than in people. This is a logical development because much of an engineer's technical training has had to do with the principles of the use of various machines of one kind or another. I realize that human nature is hard to change and if a man is more interested in machines than he is in people, it will not be an easy task to get him to develop as much interest in people as he needs if he is going to handle his job successfully. On the other hand, there are many various types of excellent training courses which can aid such a person materially in developing greater skill in understanding people and getting them to do the things that are necessary to accomplish the job at hand. Everything possible should be done to encourage the development of such skills because we must always come back to the realization that it is people, not machines, who accomplish things. Here again in your particular field of building and maintaining tracks and structures as more and more mechanical devices are used to eliminate manpower the matter of handling people becomes just that much more important. Fortunately, as machines become more complicated, people with greater intellectual ability must be employed. Because the machine operators must have greater intellectual capacity, the ability to deal with them as people becomes easier in some ways simply because it is easier for them to understand the written and spoken word than those who may have had less education or who possess less basic intellectual capacity. Therefore, again, I would repeat that the training courses designed to develop greater skill in handling people become even more important.

One other philosophy of management about which I would speak is that of planning for the future. Long-range planning is a must if we are going to meet this challenge for progress. Certainly in the area of top management, but also in the area of middle management, we must intensify our efforts to look into the future and anticipate changes which are sure to come. Unfortunately none of us possess an infallible crystal ball. On the other hand, if we do a careful job of reviewing all the available statistical facts and material which has to do with future events I am sure we can greatly improve our skill in long-range planning. Granted that even if we do make some mistakes in trying to guess the future, certainly a program of educated best guessing is better than no program at all. We can not afford to drift and to operate only on a day-to-day basis if we are going to be successful in our objectives. We on the Western Pacific have been trying to carry out a program for long-range planning, and while we know that some of our guesses will undoubtedly be wrong, I feel sure that all of our top management group will carry out their day-to-day duties and responsibilities more effectively for future results than would otherwise be the case.

Many of you may not be in the top management group, but even in a subordinate capacity it behooves you to spend a certain amount of time each day and each week trying to figure out what future developments may take place so that what you do today will be executed with the future in mind.

In conclusion, I am optimistic as to the future of the railroad industry although I have pointed out that we have many obstacles to overcome if we are going to reach our objectives. Courage, determination, resourcefulness, ingenuity and originality will be required in large measure. I am fully confident that you and other managerial personnel possess the attributes and will exercise them in such a way that the railroads will once again attain the position of dominance in the transportation field that they enjoyed for many years. To do this in the face of intense competition we now experience will be a monumental task but I know you are capable of achieving it.

I indeed appreciate the chance to talk to you and thank you for listening so patiently. [Applause]

Afternoon Session, March 15, 1960

[The meeting reconvened at 2:10 o'clock in the George Bernard Shaw Room, President Woolford presiding.]

President Woolford: Will the meeting please come to order. It is essential that we get started promptly and do what a department store Santa Claus is reported to have told one of the children who were lined up to meet him. When one of the little boys rejoined his mother after shaking hands with Santa, his mother said to him, "What did Santa say to you?"

The little boy said, "Santa Claus said 'Keep moving.'"

That's what were're going to have to do if we are to get through this afternoon's program anywhere near on time.

Discussion on Waterproofing

[For report, see pp. 425–427.]

[President Woolford presiding.]

President Woolford: I would like to call to the platform the members of Committee 29—Waterproofing, which is the committee that we had to pass over from the morning session to the afternoon session. The chairman of this committee is E. A. Johnson, engineer of bridges, Illinois Central Railroad. Will Mr. Johnson please bring his committee to the platform.

While the committee is coming to the platform, may I remind you that you still have the privilege to speak from the floor, even though we are pretty tight on time.

I would now like to turn the podium over to Mr. Johnson so he can proceed with the report of Committee 29.

Chairman E. A. Johnson: Neal Howard, in his letter of October 1, 1959, to all committee chairmen, asked if our committee was planning a special feature in conjunction with our presentation before this convention. Since waterproofing is a highly specialized subject, it was thought that a special feature on a waterproofing subject would not have general appeal. For this reason, we decided that our committee would be one to "give" so that this convention would not run beyond its scheduled length.

It was further suggested that, in order to save convention time, committees should give consideration to presenting their report in the manner used by Mr. Bechly of Committee 30 at last year's convention. Although it would be my preference that each subcommittee chairman make the report on his particular assignment and be recognized, nevertheless, when this matter was brought to the attention of the members at our last committee meeting, it was decided that the chairman should make the complete report.

First, I would like to say a few words about Pete Miesenhelder, who died last November, just a week after he had met with this committee in Pittsburgh. He was a member of the AAR research staff with the title of research engineer—concrete, but he was also research engineer—waterproofing. His death was reported in the AREA News, January–February, 1960 issue. It is with profound regret that Committee 29 expresses its sorrow at the loss of this most capable member of the AAR staff. Pete knew concrete and bitumens and was a consultant for this committee. He will be missed.

Now, I presume it will be in order for me to present the report of this committee, but before doing so, I want you to meet the chairmen of our subcommittees. Will each chairman stand and be recognized as I call his name.

R. J. Brueske, assistant division engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad, Assignment 1—Revision of Manual.

E. T. Franzen, engineer of bridges, Chicago, Rock Island & Pacific Railroad, Assignment 2—Waterproofing Materials and their Application to Railway Structures.

W. P. Hendrix, engineer bridges and building, Pennsylvania Railroad, Assignment 3—Coatings for Dampproofing Railway Structures.

W. H. Acker, Jr, structural engineer, Alfred Benesch & Associates, Assignment 4—Protective Cover and Underlayment for Membrane.

The report of Committee 29—Waterproofing, will be found in the December, 1959, Bulletin No. 554.

Assignment 1—Revision of Manual.

Chairman Johnson: Your committee is now focusing its attention on a review of Manual material toward the end that we will be in a position next year to recommend reapproval of such parts of the waterproofing specifications which do not require change, or to recommend for adoption those revisions of the specifications which are now before the committee.

Assignment 2—Waterproofing Membranes for Bridge Decks, Collaborating with Committees 8 and 15.

Chairman Johnson: Mr. Franzen, subcommittee chairman for Assignment 2, is taking the lead in rewriting Part 2—Waterproofing Membranes, of Chapter 29. This specification is being rewritten for clarity and for the incorporation of references to ASTM specifications wherever applicable.

Tests of waterproofing membranes and materials have been under way at the AAR Research Center in Chicago. Tests have been run on above-ground and below-ground asphalts and tars, as well as on felts and fabrics. The differences in performance of membranes of various plies of material have been investigated, as has glass fabric for use in membrane waterproofing. The evaluation of the test information and the completion of a report has been delayed because of the death of Mr. Miesenhelder. This work was all done under his supervision.

Assignment 3—Coatings for Dampproofing Railway Structures, Collaborating with Committees 6 and 8.

Chairman Johnson: The final report on "Factors Affecting the Penetration by Water of Bitumens and Silicone Coatings," carried on at Purdue University as a research project under the direction of Research Associate W. L. Dolch, was published as an advance report in the September–October 1959, Bulletin 552.

This study dealt with two types of water-resisting coatings in common use, bituminous emulsions and silicones. To be effective, it is essential that the barrier established by a coating of water-resistant material be capable of preventing the passage of water to that part of the structure being protected. It is also essential that such material be capable of resisting normal weathering conditions and maintain a high degree of efficiency for a long period.

The two materials studied, when used to protect a porous material such as concrete, function by entirely different mechanisms. The bituminous emulsions form a film over the material to be protected and act as a continuous impervious barrier. The silicones, on the other hand, line the pores of the material with a thin layer of resin, which prevents the entrance of water by a capillary repulsion mechanism. This mechanism is also operative in preventing the passage of water through pinholes and fine cracks in bituminous coatings.

The tests developed that an intact bituminous film will act as an effective barrier to the passage of water. It was also found that drainage of the structure is desirable, and good workmanship in applying the material is necessary to obtain the highest degree of efficiency by bituminous protection. The tests on the silicones indicate that their effective life is less than that of the bitumens.

Mr. President, if there are no questions, this concludes the report of Committee 29.

President Woolford: Thank you, Mr. Johnson. The scope of the work of your committee is necessarily limited, but the matters that you are dealing with are highly important adjuncts to the work of our other structural committees, and it is good to know that you are making real progress on your assignments.

I wish at this time, Mr. Johnson, to thank you and your committee for being so cooperative with me in arranging that I could meet with your committee today and carry out my desire of meeting at least once with every committee of the Association this year. You made that possible for me this morning. Thank you.

Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Buildings

[For report, see pp. 331–392.]

[President Woolford presiding.]

President Woolford: The next committee I would like to call to the platform is Committee 6. The chairman of this committee is S. G. Urban, architect, Texas & Pacific Railway.

Chairman S. G. Urban: Mr. President, members of the Association, and guests:

Your Committee on Buildings has 10 assignments on which to report progress or completion. The committee is also privileged to present a special feature by one of its members. We have five final reports, two of which were completed in their first year of study because the committee felt the particular information would be most helpful presented as early as possible. The report for Committee 6 appears in Bulletin 553, pages 331 to 392, incl., and members are invited to comment or ask questions on the subjects as they are presented.

Committee 6 expresses sincere sorrow at the passing of two of its valued members.

Thomas V. Pyle departed this life on April 14, 1959. He was office engineer for the Elgin, Joliet & Eastern Railway and had approximately 36 years of service with this railroad, where he was held in high esteem by his associates and many friends. He

joined the Association in 1952 and became a member of Committee 6 in 1953. This committee's memoir to Thomas V. Pyle conveys our high regard and deepest sympathy to his loved ones, many friends and associates.

Arnold A. Melius departed this life on January 4, 1960. He was architect for the Northern Pacific Railway and had approximately 16 years of service with this railroad, where he was held in high esteem by his associates and friends. He joined the Association in 1949 and became a member of Committee 6 in 1956. This committee's memoir to Arnold A. Melius conveys our high regard and deepest sympathy to his loved ones, many friends and associates.

As a result of the work and cooperation of the subcommittee chairmen and committee members, I can now present informative and interesting reports on the Building Committee assignments.

Assignment 1—Revision of Manual.

Chairman Urban: Report on Assignment 1 will be made by Subcommittee Chairman C. S. Graves, assistant steam heat and water service engineer, Atchison, Topeka & Santa Fe Railway, Topeka, Kans.

C. S. Graves: Mr. President, members of the Association, and guests:

During the past few years, your committee has completely reviewed the specifications for roofing contained in Part 10 of Chapter 6 and has found them inadequate and obsolete in many respects. This year these specifications were rewritten by the subcommittee with the able assistance of W. G. Harding of our committee. Your committee now presents the new specifications for adoption and publication in the Manual to take the place of material now appearing on Manual pages 6–10–1 to 6–10–29, incl.

Mr. President, I move the adoption of the new specifications as contained in Bulletin 553, pages 332 to 363, incl., to take the place of existing documents.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 2—Specifications for Railway Buildings.

Chairman Urban: Under Assignment 2 a specification for concrete masonry walls has been written, but submission to the Association has been deferred until next year so as to incorporate the recommendations for expansion, contraction and control joints in masonry block walls to be made under Assignment 5 that will be reported later. Our subcommittee chairman for Assignment 2 is H. T. Seal, engineer of buildings, Chesapeake & Ohio Railway, Richmond, Va. Mr. Seal could not be present today, but the committee recognizes his fine work as subcommittee chairman.

Assignment 3—Prefabricated Metal Buildings for Railway Use.

Chairman Urban: The subject of prefabricated metal buildings for railway use is being studied by the committee. A preliminary draft has been written to which it is proposed to add a general specification for basic metal building requirements, including design and construction. The chairman of this subcommittee is R. E. Lilliston, architect, Kansas City Southern Railway, Kansas City, Mo. Mr. Lilliston, will you please rise.

Assignment 4—Wind Loading for Railway Building Structures.

Chairman Urban: The work on Assignment 4 is being progressed by the AAR research staff. The committee has in process the analysis of data and the preparation of a report covering field tests conducted by the AAR research staff on a structural frame floodlight tower on the Santa Fe Railway in Clovis, N. Mex. It is proposed that additional field tests be made on a tall pipe floodlight tower. These tests on towers in different parts of the country will be reported with recommendations when the data

have been compiled and studied. It is my pleasure to introduce the chairman of this Subcommittee, G. A. Morison, assistant engineer of buildings, Canadian Pacific Railway, Montreal, Canada. Mr. Morison, will you please rise.

Assignment 5—Expansion, Contraction and Control Joints in Concrete and Masonry Block Buildings.

CHAIRMAN URBAN: The report on Assignment 5 will be made by the subcommittee chairman, S. M. Bielski, assistant superintendent of construction, Erie Railroad, Cleveland, Ohio. Mr. Bielski will also introduce the speaker for our feature presentation.

S. M. BIELSKI: Mr. President, members and guests:

This is a final report, submitted as information. The cracking of walls constructed of concrete masonry is regarded as one of the major problems in the use of masonry units. The need for summarizing the voluminous literature covering the various theories relative to cracking in concrete masonry construction and means to help prevent cracking was apparent, and the members of this committee have endeavored to make available to the architect or engineer a concise report for ready reference.

No single recommendation regarding the positioning and spacing of control joints in masonry walls can be applied to all structures because such factors as length of walls, architectural details and local experience must be considered, and each building design must be analyzed to determine potential wall movements. Although control joints are advocated for use to minimize cracking due to movements which tend to take place in concrete masonry walls, they are expensive, require maintenance and often are unsightly if not properly installed. They should, therefore, be limited in use as far as practical. It is highly desirable that the architect, engineer and contractor continually insist on high-quality concrete block and that approved construction practice be strictly adhered to so that crack-free concrete masonry structures may be obtained.

Where local experience indicates it is necessary to use control joints to obtain a successful concrete masonry structure, close cooperation between the architect and structural engineer is important and necessary to assure both a workable and an attractive arrangement of control joints.

As a special feature, I am pleased to present William C. Panarese, railways representative, Structural and Railways Bureau, Portland Cement Association, who is an associate member of Committee 6. He will present an adaptation of our report on control joints in concrete masonry buildings. Mr. Panarese.

Control Joints in Masonry Block Construction

By W. C. Panarese

Railways Representative, Portland Cement Association

Mr. President, Mr. Chairman, gentlemen and guests of the Association:

I'm very pleased to have this opportunity to discuss with you briefly some of the important aspects of control joints for concrete masonry construction.

The use of concrete block in constructing railroad buildings is increasing rapidly, primarily because of the economy, fire resistance and availability of this building material. More than 2¼ billion units were used in all types of construction in the United States last year.

In some areas of the country, the advantages of concrete masonry buildings are somewhat offset when walls develop cracks. Cracks in masonry walls are in effect con-

trol joints themselves; however, they usually disfigure a wall and cannot be easily repaired.

Cracking can be controlled by proper use of control joints. These joints are continuous from the bottom to the top of the masonry wall and constructed through the entire thickness of the wall.

Before going into the "where" and "how" of control joints, let's examine briefly what causes cracking in concrete masonry buildings. One or a combination of the following conditions build up serious stresses which may result in wall movements and cracking.

1. Expansion and contraction due to temperature changes and variations in the moisture content of the masonry.
2. Unequal settlement of the building foundation.
3. High concentrations of applied loads, such as roof members.
4. High stresses in masonry at weakened wall sections.
5. Localized built-in restraints, such as columns and intersecting walls.

Since concrete masonry is not a perfectly elastic material, the correct locations for control joints cannot be predicted with mathematical accuracy. Specifying control joints becomes a matter of judgment based on local experience and past performance of the concrete block to be used. If cracking in masonry structures in your area is a problem, then building designers should provide control joints. The following "rules of thumb" are intended as a guide to designers for locating and spacing control joints.

There is a relationship between the height of a concrete masonry wall and the control joint spacing. This spacing should be no more than 1¼ times the wall height for a plain wall with no doors, windows or columns.

At all abrupt changes in wall height, a concentration of stresses will likely occur. A control joint should be placed to relieve these stresses and prevent cracking.

In buildings with cast-in-place concrete foundations which contain joints, the joint must be continued up through the concrete masonry wall.

Similarly, expansion joints in roof slabs should be extended down through the masonry walls.

Openings, such as doors and windows, weaken a masonry wall and are likely points of high stress and cracking. Control joints should be placed at these openings. Below windows, the joints extend directly below the sides of the opening. Above doors and windows they are offset to the ends of the lintels.

As a rule of thumb, openings less than 6 ft wide need a joint along only one side. Wider openings should have joints along both sides.

A control joint is necessary at abrupt changes in wall thicknesses. This occurs at such points as the juncture of a single-story wing with a multi-story building or at columns or pilasters.

The same general rules for exterior walls apply for control joints in concrete masonry partition walls. Where joints occur in concrete floors, they should extend up through the partition walls. Always use a control joint at intersections of masonry walls.

Intersecting masonry walls should never be tied together with a mortar bond. One wall should terminate at the face of the other with a control joint. Use some form of load transfer device for stability. A steel tiebar ¼ in thick is often used to provide this stability without restraining the walls from moving. Tiebars are bent at each end and inserted at about 4-ft intervals vertically.

The ends of the tiebar are embedded in mortar by filling the appropriate cores in the block.

Steel tiebars are used for load-bearing walls. However, if the intersecting wall is a non-load-bearing partition, galvanized hardware cloth will do the job. It is placed in every other mortar course.

The intersecting walls need not be laid up simultaneously. Strips of hardware cloth can be placed in one wall and incorporated in the other wall when it is built later.

Let's next consider the various ways of constructing control joints. One popular method involves the use of a special tongue-and-groove block. The tongue and groove provides excellent lateral stability to the wall.

Tongue-and-groove block are laid up exactly as regular block using half-size and full-size units to form continuous vertical joints.

A second method of forming control joints makes use of regular open-end block. This is referred to as the "Michigan" control joint. A strip of building paper is curled into the core formed by two adjacent units. The core is then filled with mortar to form a plug which transmits lateral loads. Since the paper prevents bond, the control joint can allow for small longitudinal movements in the wall.

There are other methods of forming control joints, but the tongue-and-groove block and the Michigan control joint are most highly recommended.

Joints subject to weathering or those where appearance is a factor should be caulked with an elastic caulking compound. Before the mortar becomes too hard, it is raked out to a depth of ¾ in. The inner faces of the joint should be primed with shellac or other sealing materials to prevent the dry block from absorbing oils from the caulking compound.

Caulking compound is then applied with a gun or pointing trowel. Recommendations from the manufacturers of these materials should be followed.

Proper care during planning, construction and caulking of control joints will lead to a functional wall with joints that will be inconspicuous, weathertight and maintenance-free for many years. [Applause]

Chairman Urban: Thank you, Mr. Bielski, for the report on Assignment 5, and thank you, Mr. Panarese, for a most interesting presentation.

Assignment 6—Modernization of Power Plants and Heating Systems for Railway Buildings.

Chairman Urban: Work on Assignment 6 is well advanced. In its first year of study, the subcommittee has circulated a questionnaire and written a preliminary draft on the assignment. After further study, a report will be submitted next year as information. It is my pleasure to introduce D. A. Bessey, assistant architect, the Milwaukee Road, Chicago, the subcommittee chairman. Mr. Bessey, will you please rise.

Assignment 7—New Structural Systems for Railway Buildings.

Chairman Urban: The report on Assignment 7 will be presented by Subcommittee Chairman G. H. McMillan, engineer bridges and structures, Soo Line, Minneapolis, Minn.

G. H. McMillan: Mr. Chairman, members and guests:

Your committee submits as information a progress report covering only new types of masonry construction. Types of construction other than masonry will be covered in a later report, on which the subcommittee is now working.

The objective of the work has been to list and describe briefly the newer developments in methods and materials of construction and to point out their application to railway buildings. This report should help architects and designers select a type of building best suited to the purpose for which it is to be used.

Prefabrication is the key to many of the savings available in new construction methods. Quantity production of units cuts labor costs both in manufacture and erection, and the quality of such units is uniformly superior to those produced and erected by older methods.

Assignment 8—Infra-Red Ray Heating, Collaborating with Electrical Section, AAR.

Chairman Urban: The work to be undertaken this year under Assignment 8 is to collect data on electric heaters. It is proposed to submit some conclusions on this type of heater to complete the progress report made to the Association in 1959. It is my pleasure to introduce the chairman of this subcommittee, J. W. Gwyn, assistant engineer, Missouri Pacific Railroad, St. Louis, Mo. Mr. Gwyn, will you please rise.

Assignment 9—Architectural Requirements of Railway Buildings for Housing Electronic Data Processing Machines.

Chairman Urban: The report on Assignment 9 will be presented by the subcommittee chairman, G. J. Bleul, assistant engineer of bridges and buildings, Baltimore & Ohio Railroad, Baltimore, Md.

G. J. Bleul: Mr. President, members of the Association, and guests: The report on architectural requirements of railway buildings for housing electronic data processing machines is submitted as information.

Electronic data-processing machines are being used by a number of railroads to handle various accounting procedures in an efficient and economical manner. An installation requires detailed study and consideration of numerous architectural, structural and mechanical features to house these machines in a present or new building.

Requirements such as space, location, floor loading, air conditioning, flooring, heating, acoustical ceiling, partitions and power are briefly discussed to provide a guide for future data-processing centers.

Electronic machines require a multitude of interconnecting power and signal wires, as well as numerous air, vacuum, water, steam and drain lines in the machine areas. Use of a raised or false floor—under or around the machines—with removable panels, provides accessibility, protection and flexibility for future expansion of these facilities.

Air conditioning is necessary to dissipate the heat generated by various electronic machines, and to provide a high degree of humidity and dust control. Usually 75 deg temperature and 40 to 60 percent humidity are necessary throughout the year for satisfactory operation of the critical machines, and for the storage of tapes which are used to process information.

When a suspended ceiling is used, it should be composed of non-dusting materials and have good acoustical qualities with recessed fluorescent lighting of normal office intensity. The space above the ceiling may be utilized as a return air plenum as well as for the supply ducts of the air conditioning system and various service lines.

Extensive partition work is necessary to provide several rooms for the component parts of the data-processing system, offices. and maintenance, equipment, tape storage and power areas.

The power-center area contains, where appropriate, the necessary motor-generator sets, transformer, power control and supply units, air compressors and vacuum pumps for the operation of the electronic machines. In selecting a site, floor loading, vibration, noise and adequate ventilation require detailed study and consideration.

Planning includes a survey of present electrical power to determine whether a new power supply is necessary to meet all the requirements.

The data-processing center should have fire protection equipment, such as carbon dioxide manual extinguishers or automatic systems, which will not cause damage to the electronic machines.

Installation of a data-processing center requires close cooperation, particularly between the engineering, electrical, communications and accounting departments of a railroad and the electronic machine manufacturer.

Mr. President, this concludes the report on Assignment 9.

Assignment 10—Consolidations of Buildings at Railway Terminals.

CHAIRMAN URBAN: The report on Assignment 10 will be presented by the subcommittee chairman, F. D. Day, area engineer—structures, Pennsylvania Railroad, Pittsburgh, Pa.

F. D. DAY: Mr. President, Members of the Association and guests: This report is for information only.

One of the most important attitudes on all railroads in the country today is the attitude that the railroads individually take toward streamlining their properties. No one can logically defend the proposition that the railroads generally are expanding their facilities at a great pace. The operating capacity for railroads is more than adequate for the traffic now being handled. The emphasis is, and should be on the forward-looking railroads, to streamline, consolidate and operate with a minimum amount of structures and right-of-way properties to achieve maximum production of transportation with a minimum of maintenance and operating costs. Your subcommittee has attempted to point out some sign posts in this direction.

Many of us that have been working through the last 15-year revolution sometimes lose sight of the overall changes that have been made in the railroads. We tend to go from day to day and year to year absorbing the changes as they occur. It is necessary every once in a while to stop, stand back, look at what has been done and take out a crystal ball to see what can be done for the future.

If we can operate without all the minor passenger stations and freight stations that we had to have in the past, if we can operate with a large consolidated station using subsidiary truck lines to handle our local freight deliveries, if we can service our passenger trains in the terminal, that is now too big for passenger operation, and if we can streamline our car shop operation by putting it on a production-line basis, we will begin to catch up with some of the progress that has been made in automatic hump classification and retarder yards.

Our subcommittee report highlights most of these suggestions. It has been printed in the Association Bulletin, and we recommend it for your close attention.

PRESIDENT WOOLFORD: Thank you, Mr. Day. Your report will be accepted as information.

CHAIRMAN URBAN: Mr. President, this completes the reports for Committee 6, but I would like to make several acknowledgments expressing gratitude for help in carrying on the committee's work.

Our retiring secretary is D. W. Converse, retired bridge engineer, Akron, Canton & Youngstown Railroad, Canton, Ohio. Thank you, Mr. Converse, for the great help you have been to this committee. We wish you well in your new status.

Our new secretary is D. J. Murray, engineering draftsman, Chicago & Western Indiana Railroad, Chicago, who has been acting secretary since last September.

The chairman of Subcommittee A—Recommendations for Further Study and Research, and our committee vice chairman, is K. E. Hornung, architect, the Milwaukee Road, Chicago, who has been a great help to me.

I also express thanks to the executive secretary and his staff, and to the office of the Association this past year for their leadership.

President Woolford: Thank you, Mr. Urban. Your committee has produced a number of interesting reports and it is to be especially commended for its work in rewriting our roofing specifications. And thank you, Mr. Panarese, for your interesting and informative presentation on control joints in masonry block construction.

Mr. Urban, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Highways

[For report, see pp. 269–282.]

[President Woolford presiding.]

President Woolford: Moving along, our next committee to report is Committee 9—Highways, the chairman of which is J. M Trissal, vice president and chief engineer of the Illinois Central Railroad, Chicago. Mr. Trissal, I am pleased to turn the microphone over to you, and you may carry on the presentation of your report as you see fit.

Chairman J. M. Trissal: Mr. President, members and guests: Hal H. Hale, assistant to vice president, AAR, will introduce the speaker on our special feature.

Hal H. Hale: President Woolford, Chairman Trissal, I had a honey of an introduction here for the speaker this afternoon, but as the president has said, we are pressed for time, and our speaker has to be back in Washington tonight; so, Mr. Tallamy, you are going to escape a large part of my introductory remarks. However, there are a few things I would like to say about him.

His name is Bertram D. Tallamy and he is federal highway administrator, Bureau of Public Roads, Washington, D. C. His friends call him Bert. His relatively few enemies have some odd names that they call him an occasion, but I hope that you will call him Bert, as I have had the privilege of doing for almost two decades.

When I first met him, I had a lot more gray hairs than I have now and he had a lot less. He has gotten those since he has been in Washington.

Now, in addition to having to get back to Washington in a hurry this afternoon, this man was responsible last year for paying out in federal funds to the state highway departments, something approximating three billion dollars. I'm going to shake him when he gets up to see if he rattles. But if he is as nervous as a long-tailed cat in a roomful of rocking chairs, that explains part of it.

Here, in the presence of all you people as witnesses, I am going to ask him to support me as a referee in a matter that is going to be on his hands one of these days, and I certainly do want to be a referee. We have a new State Highway Department in Alaska, the new State of Alaska. The Federal Bureau of Public Roads is going to be dealing with them as a state highway department. They have also in Alaska a federally owned railroad, the Alaska Railroad, and I want to be a referee when they go to bat on paying for some of the grade crossing projects in connection with that railroad. [Laughter] So I'm asking his support now, in front of all of you as witnesses, to name me as a referee.

Now, gentlemen, I am sure you are going to enjoy this speaker and, without further ado, I will present him to you. Bert Tallamy, federal highway administrator in Washington. Mr. Tallamy.

Federal-Aid Highways and the Railroads—a Status Report

By B. D. Tallamy
Federal Highway Administrator, Bureau of Public Roads, U. S. Department of Commerce

Mr. Chairman and gentlemen:

I am a little disappointed. I thought Hal was going to take all the time this afternoon that was available for my comments, and all I would have to do would be to stand here and enjoy it. But would I enjoy it, Hal? I'm not quite sure.

He talks about him not having as many gray hairs as he did some two decades ago and my having less then than I have now. Well, certainly it is true that I had less then and he has less now. So I'm not quite sure whether it is better to be in the railroad business or in the highway business, because he has lost his hair in the past few years while my hair has turned grayer. At least, I still have mine, but I'm not so sure for how long.

The project that we are engaged on is pretty rough, and the dollars and cents angle that Hal mentioned a few minutes ago is brief indication of some of the problems that we have. You worry about grade crossing elimination and protective devices and things of that nature. You ought to be in my spot, when the governors and the mayors and the railroadmen and local officials and other people come in and everybody wants a highway system but they each want it in a different location or in a different manner. Brother! it is really tough. But we are making substantial progress, improving our relationships with the various agencies with which we have to do business, and I am especially happy to be able to talk to the people that are in a related profession, such as you gentlemen today, and just tell you a few of the accomplishments and a few of the problems, and to touch on one which is rather intimately associated with your own business.

As you know, we have every reason to expect that the transportation industry of the United States is going to have an ever-increasing army of Americans engaged in the moving of people and of commodities from one place to another. Now, although this moving is to be done in various ways, certainly it all has a common goal, and that is the moving of people and commodities as quickly as possible, as safely as possible, and at the lowest possible cost. That is our common objective.

There are now five principal means of transportation—the railway, the highway, the waterway, the airway, and the pipeline. I was going to say "pipeway," but I don't think that term has yet got into the dictionary. None of us would be surprised, I'm sure, if the five modes of transportation I have named were joined within a few years by something called the "spaceway."

The demands for transportation have been growing not only faster than the gross national product but faster than the population. We all travel a good deal more than our fathers did, and we wear and eat things from farther and farther away. If the trend lines prove to be true forecasts, this growing per capita demand for transportation is bound to continue. It is related not only to an expanding economy and population but to such less tangible factors as more widespread education and increased leisure time.

The various kinds of transportation certainly supplement one another. People and things often reach their destination by more than one form of transportation. Especially is that significant in the railway-highway business. Not only for the present, but for the future, we who provide the different surfaces for wheels to turn on need to coordinate our various activities and do so with the maximum efficiency and to the maximum extent possible.

One way in which the railway and highway groups have pulled together is in the development of T.O.F.C., more commonly called piggy back service, which is growing in popularity. Of course, you people in the railway business know about this much better than I, but I am deeply impressed with the phenomenal rate of growth which is taking place in that field. Actually, movements of that nature increased 50 percent in 1959 over 1958, and practically 150 percent over the year 1955, or 148 percent, to be exact. No doubt this trend will continue.

Another field in which the railroad industry and the highway business cooperate, and in which it is most important that we do so, obviously, is in the removal of grade crossing hazards and the protection of others. You are all familiar with the Bureau of Public Roads Policy and Procedure Memorandum, 21–10, on this subject. The provisions provide that so far as federal aid elimination work is concerned, where the railroads do benefit as a result of the project, their contribution shall be 10 percent. Where they do not receive a benefit as a result of the work, their contribution is zero.

Now, it has been found recently in the carrying out of this particular procedure that it does work a hardship on the railroads in some cases. For example, when we change the characteristics of a regular highway into a freeway, with complete control of access, we must eliminate all the crossings that are at grade with the railroad. Now, in the case of spurs, branch lines, switching and terminal lines, where the train movements are very light and where the speed of those movements is slow, the elimination of those crossings at grade is not beneficial to the railroads, yet it is essential from the highway point of view. Accordingly, we have been working on that problem in recent months and have arrived at a decision which is now in effect and which is so important to you that I think instead of extemporizing, as I am now, I shall read to you the precise language of the memorandum bearing on this subject which has gone out from my office to the field. I am now quoting:

"A project for the elimination of an existing intersection of a railway and highway at grade shall be considered of no cognizable benefit to the railroad and the railroad shall not be held liable for any part of the cost of the project when all of the following conditions exist at the time the project is undertaken:

"(a) The project is undertaken as part of the conversion of an existing highway to a freeway with full control of access;

"(b) Such conversion requires the elimination of the existing railway–highway intersection at grade, which elimination would not be considered essential except for the geometric and construction standards applicable to such freeways;

"(c) The railway–highway crossing involves only a spur track, branch line, or switching and terminal line on which train movements are at low speed and the total number of train movements has not exceeded six on any day during the preceding twelve months;

"(d) There is not in force either an agreement between the State Highway Department and the railroad or an order rendered by a state public utilities commission or other legal authority, providing for the elimination of the railway-highway crossing; and

"(e) Automatic signal devices have not been installed or ordered at the crossing."

Now, if automatic signal devices have been installed or ordered but the other four conditions exist, elimination of the grade crossing is regarded as having a cognizable benefit to the railroad, and the railroad will pay a share of the construction cost. The railroad's contribution will be a lump sum equivalent to the computed present worth of 10 years' estimated savings on maintenance through the discontinuance of the automatic signal devices.

It is expected that this policy will soon be incorporated in an amendment to PPM 21-10. In the meantime it is fully in force.

It is interesting to look back over the past 25 years and see what this cooperation I mentioned has actually brought forth in connection with benefits to everyone who travels. In the fiscal years 1934 through 1959, in that 25-year period, more than 17,000 railroad-highway crossings at grade have either been eliminated or protected—a wonderful record, indeed. They were financed from federal aid and federal emergency funds and from state highway funds, and, of course, the state highway departments in many instances received substantial contributions from the railroads as a result of their share. Of the 17,000 crossings I mentioned, some 6500 represented projects for the actual elimination of the crossings; 1100 of them represented the reconstruction of old structures which had become obsolete and deteriorated and were hazardous; and another 9500 crossings were protected.

The total cost of all of this work amounted to about $1,200,000,000, of which the federal government paid almost a billion—$981,000,000, to be exact—the states and the railroads paying the difference.

Now, the construction of the National System of Interstate and Defense Highways, which we hear so much about, will involve the elimination of another 2000 railroad grade crossings. More than 1800 of these will be in rural areas. The number which will be in urban areas is not yet exactly known, but we do expect to get precise figures on these from the estimates of cost which are now being developed for the completion of that system.

It may come as a surprise to you, as I know it does to a great many people, that actually right now there are 7570 miles of express highways completed and open to traffic on the Interstate Highway System. And of this amount, 3360 miles have been completed as a part of the recent federal aid highway program, with the federal government contributing about 90 percent of the cost and the states, 10 percent. The remaining 4210 miles were built by the states, by toll road and other authorities, and municipalities, prior to the 1956 Act.

In addition to the segments which are presently open to traffic, that 7570 miles I just mentioned, 4770 miles are right now under construction, and right-of-way acquisition and preliminary engineering are being advanced on another 18,370 miles.

We have the so-called ABC program under way, which also involves you and the protection of crossings, resulting from the expanded 1956 Act, going along satisfactorily. It is on a 50 percent federal—50 percent state basis, and during the period between July 1, 1956, and today, we have completed 96,000 miles of those roads, which, along with the Interstate System I mentioned, amounts to about 102,000 miles of highways completed in a 3½-year period—really quite a remarkable record. And the total amount of money involved in work of all classes, including state and local communities, state, railroad and federal funds, is about 13.2 billion dollars.

Now, the Interstate System, which is the one we think of so often in regard to the highway program, can be said to be on schedule, although we are now undergoing a moderate slow-down for financial reasons. The law requires, of course, that all federal aid going to the ABC program, to the Interstate Program, to our elimination projects, must come from the Highway Trust Fund, which, in turn, is supported solely through taxes upon gasoline, diesel fuel, trucks and some other highway user taxes. We are now carrying on, however, a substantial program, indeed, and one which is keeping reasonably well on schedule.

There are several factors involved in regard to the magnitude of the program which I might just take a minute or two to explain, in view of the fact that you undoubtedly are interested in the advancement of this program from one phase or another, and many of your friends throughout the country also will be asking you about it.

You may find interesting the fact that we did have a financial problem last year, which did cause this cutback in the advancement of the work, and some may relate it to the increased cost of the system as developed by an estimate in 1955 and presented to the Congress in 1956. And you gentlemen, being engineers, will recognize that an estimate prepared in six weeks' time, involving 40,000 miles of construction, could not be too accurate. It was more of an informed guess, and there was an increase in the estimate as submitted to the Congress, as might be expected, in 1958, and many people have felt that was the financial problem, which you heard discussed last year a great deal.

It had nothing whatsoever to do with it. The problem that caused this cutback from the authorized rate of construction proposed by Section I of the 1956 Act and the 1958 Act came about because in 1958 the country appeared to be going into a recession; at least some thought so, and the Congress, in an effort to stimulate the economy, expanded the highway program and directed that $1,600,000,000 more of construction be placed under way than the Trust Fund could liquidate with the revenues that were going into it. Naturally, the next year and the next year and the next year, the contractors had to be paid, and that created a big demand on the Trust Fund and, as a result of that demand, last year, in order to keep a program of any size at all rolling, the President recommended a 1½-cent gasoline tax increase for the Trust Fund.

After considerable deliberation, the Congress gave a 1-cent gasoline tax increase up to and including fiscal 1961, which means until the last of June of next year. After that, the Law which Congress passed last year would provide for certain diversions of funds from the general funds to the Trust Fund up to and including fiscal 1964.

However, that may or may not take place. Actually, we expect that a long-range financing plan will be considered by the Congress next year, and they will have at least a six months' period for the development of such a plan prior to the need for any diversion of funds from the General Fund to the Trust Fund, and it is hoped by the Administration that some plan will be developed whereby that will become unnecessary.

In order to lay the groundwork for the development of such a plan, we are submitting to the Congress next year, in January, a new estimate of cost for completing the Interstate System. This will be based upon four years of actual experience in construction and many thousands of miles under contract and actually completed, and many more thousands of miles of highways which have actually been surveyed and have detailed plans well along towards completion; and of the remaining few thousand miles, two or three, the highways will be definitely located; estimates placed upon a definite location can be quite accurate. Therefore, we anticipate that we will be in a position to present to the Congress a most accurate estimate of cost for completing the system next year, which will be one of the foundation piers for the development of a long-range financing plan.

The other pier of this foundation will be a report which has been under way for the past 3½ years and will be completed and submitted early in January also, which has to do with highway user benefits and also the non-user benefits of the highway system. So the Congress may have before it at that time the estimated cost of completing the system plus the benefits that non-users and users derive from the system. And, of course, they have the known taxes which are now going into the Trust Fund,

and with that scientific, factual information before them, they should be able to develop a long-range financing plan for the completion of the system and carrying on necessary highway work in a scientific, proper and equitable manner. And I might point out in passing that I anticipate the new estimate of cost will not be higher than the other. I am sticking my neck out a little bit on that, because to date our record has been that the contracts awarded and the final payments for them have been about 5 percent apart as a national average.

One other thing you may be interested in is the road test being conducted by the Highway Research Board and the American Association of State Highway Officials. The Association of American Railroads has official observers assigned to this project, so you are quite familiar with the details which are being developed. This also will be a partial foundation for the economic report that we shall submit to the Congress next year regarding the equitableness of the highway user taxes and non-user taxes. Also, it will form the basis for the report that we must submit to Congress next year in January, on the 3rd of January, as a matter of fact, under the Law, regarding the sizes and weights of motor vehicles on the highway system, and the Committee on Highway Transport of the American Association of State Highway Officials is now studying that matter preliminary to further report on the tests of the roads. Surely, however, no information and no conclusions will be drawn from the test road until they can be, and we are expediting the number of axle load movements on the test road to the maximum possible.

It is my responsibility as Federal Highway Administrator to see that the intent of the law is carried out properly. I don't make the law, but it is my responsibility to see that it is carried out and that the rules and regulations and the ground rules pertaining to it are followed. The actual building of the System rests with the states and the state highway departments. They are the ones that make the detailed designs and supervise the construction, and I am sure you have found and you will continue to find it to your companies' advantage to continue a very close relationship with the state highway departments.

It seems to me also that the states could gain a great deal by advising you what part of their highway construction programs may affect your operations or your construction programs at the time they submit their programs to the Bureau of Public Roads. Thereby, you will be able to solve your own financing, budgeting, engineering and personnel problems, and other problems which you may have, operational in nature, to conform with the plans of the states, so there will be no unnecessary delays or confusion or expense on the part of the railroads or the states.

Our personal relations—and when I speak of personal relations, I mean the Bureau of Public Roads with the Association of American Railroads and with your Association—have been very cordial and helpful in every respect. We appreciate particularly the tremendous amount of work which your Association did with us in the development of this very important PPM 21-10 which I mentioned just a little while ago. It vitally affects you and it vitally affects us, and the way that your Association cooperated with us and the way the Association of American Railroads cooperated with us on this most important work was an example of how private industry and government can work together, hand in hand, to bring about good results. It is a real example, and I personally hope that we can count on your continued cooperation; you can certainly count on ours. Thank you. [Applause]

[Vice President Brown assumed the chair.]

Chairman J. M. Trissal: Our speaker has a great many problems demanding his attention back in Washington and, with the permission of Vice President Brown, I would suggest that Mr. Tallamy be allowed to leave the platform.

We will now proceed with the reports of Committee 9.

I regret to announce the recent death of Frank Miller, consulting engineer, Greensboro, N. C., who has long been a valued member of this committee.

MEMOIR

Frank Thomas Miller

Frank Thomas Miller consulting civil engineer, Greensboro, N. C., passed away in his home on March 5, 1960, of a heart attack.

Mr. Miller was born May 31, 1884, at Bethania, N. C. He attended Milligan College, Tennessee, and was graduated from A&M College, now North Carolina State College, receiving a BS degree in Civil Engineering. Mr. Miller started his association with railroading in 1905 with the Southern Railway at Charlotte, N. C. He held various positions at Danville, Va.; St. Louis, Mo.; Knoxville, Tenn.; and finally in the chief engineer's office in Washington, D. C.

During World War I, when the government took over the railroads, Mr. Miller was assigned to the corporate interest of the Southern and put in charge of the engineering department under the director general of railroads. After the war, he was promoted to chief engineer of construction with headquarters in Charlotte. Subsequently, he resigned from the company and established a private consulting practice in Greensboro. As a consulting engineer he was a specialist in grade crossing elimination in cities and handled the engineering work for the A&Y (Atlantic and Yadkin Railway, which is controlled by the Southern) to a considerable extent for several years. On November 1, 1946, he assumed the role of chief engineer of the A&Y along with his private practice.

Mr. Miller joined the American Railway Engineering Association in 1938 as an associate member and was transferred to member in 1946. He was a member of Committee 9—Highways, from 1947 to the time of his death. He was a life-long member of the Bethania Moravian Church, Forsythe County, and attended the First Presbyterian Church in Greensboro. He was a 32nd degree Mason and Shriner. Mr. Miller was also very active in the American Society of Civil Engineers and was awarded a life membership in 1955.

Surviving are his wife, the former Louise Davis; a son, Thomas Miller, Jr., of Charlotte; a daughter, Miss Louise Davis Miller; a sister, Mrs. R. M. Cox of Winston-Salem; and three grandchildren.

Mr. Miller lived an active, creative and rewarding life both in his railroad career, his consulting career and in his community. He was a man of friendly personality, high purpose, and steadfast loyalty to his work and to his friends. He enjoyed the respect and esteem of everyone with whom he came in contact. He had a rich life and when he died at age 75, the engineering profession and the community where he served and lived so long suffered a great loss.

Chairman Trissal: The report of Committee 9 is published in Bulletin 553, starting on page 269. This year Committee 9 is reporting on four of its assignments. Work is progressing on the others.

Assignment 2—Merits and Economics of Prefabricated Types of Highway–Railway Grade Crossings.

CHAIRMAN TRISSAL: R. E. Nottingham, division engineer, Louisville & Nashville Railroad, chairman of Subcommittee 2, will present a brief progress report.

R. E. NOTTINGHAM: Using information furnished by various railroads, your committee prepared a table of estimated costs to install and maintain various types of highway–railway grade crossings. This table is printed on page 270.

As stated in the report, these estimated costs are not considered as final and may be changed by more accurate figures on maintenance costs and service life of the materials used. They are primarily to get comments and criticisms and emphasize to maintenance of way officers the cost burden being assessed the railroad by the accelerated highway programs.

Are there any questions or comments?

This report is offered as information, and your committee recommends the subject be continued.

Assignment 3—Merits of Various Types of Highway–Railway Grade Crossing Protection, Collaborating with Signal Section, AAR.

CHAIRMAN TRISSAL: J. A. Jorlett, area engineer—structures, Pennsylvania Railroad, is chairman of Subcommittee 3 and will present the report.

J. A. JORLETT: In 1957, the Armour Research Foundation, under the direction of the AAR Research Department, made a study of the characteristics of 2,291 Rock Island highway–railway grade crossings in Iowa. The prediction equation evolved produced inconclusive results, which your committee felt was due to insufficient data, especially with reference to crossings with automatic-type protection.

In order to get more information, your committee has arranged with the State of Ohio to get the results of its survey of the physical characteristics of all the highway–railway grade crossings in Ohio. In addition to this information, the 14 railroads operating in Ohio which have the largest number of crossings have furnished their grade crossing accident records for the period 1948 to 1958. The Armour Research Foundation is classifying these data and preparing summary tables for the investigation of the correlation between accidents and grade crossing characteristics.

Since funds for this project are included in the 1960 Engineering Division Research Budget, the statistical work on this study can be completed, and we are hopeful that it will produce reliable risk factors and show the effect of up-graded protection on accident rate.

Are there any comments or questions?

This is a progress report submitted as information. Your committee recommends the assignment be continued.

Assignment 4—Relative Effective Visibility of Highway–Railway Crossbuck Signs of Various Sizes, Colors and Materials.

CHAIRMAN TRISSAL: T. M. Vanderstempel, city traffic engineer, Saginaw, Mich., is chairman of Subcommittee 4 and will present the report.

T. M. VANDERSTEMPEL: Your committee has reviewed a number of crossbuck signs of various sizes, colors and materials to determine their relative visibility both at night and in the daytime. The two most outstanding signs have been placed in a highly industrialized area to determine the effect of smoke and soot on their relative visibility.

Are there any questions or comments?

This is a progress report submitted as information. Your committee recommends the assignment be continued.

Assignment 8—Recommended Protection at Highway–Railway Grade Crossings Where One-Way Traffic on the Highway Crosses one or More Tracks on the Railway.

Chairman Trissal: Due to the absence of D. W. Hughes, Michigan Public Service Commission, chairman of the subcommittee, the report will be presented by J. E. K. Krylow, retired engineer of signals and communications, Pennsylvania Railroad.

J. E. K. Krylow: A report on this assignment was published in Bulletin 546, November 1958, pages 249 to 258, incl. Due to circumstances beyond the control of your committee, this report was not presented at the 1959 Convention. Your committee now submits the following as a final report with recommendations for adoption and publication in the Manual.

The plans published in Bulletin 546 were revised to show a space between the ends of the automatic crossing gates and were again published in Bulletin 553, November 1959, pages 274 to 282, incl. These plans have the approval of the Signal Section, AAR.

Mr. Chairman, I move that the revised plans, designated as Figs. 3A to 3J, incl., (excluding Fig. 3I), be adopted and published in the Manual as pages 9–3–6.1 to 9–3–6.9, incl., along with revisions of certain other material in Chapter 9, as follows:

On page 9–3–1 under Recommended Use of Highway–Railway Grade Crossing Signals, in the second column of the table, at the end of the item reading "Cantilever flashing-light signal, as shown on pages 9–3–12 or 9–3–13," add the words "located as shown on pages 9–3–6.2, 9–3–6.3, 9–3–6.5, 9–3–6.6 and 9–3–6.7."

To the corresponding item in the third column, add the following page numbers: 9–3–6.2, 9–3–6.3, 9–3–6.5, 9–3–6.6, and 9–3–6.7.

On page 9–3–2 under "Requisites for Highway Grade Crossing Signals": Add the following to the paragraph under Art. 1. Purpose: "for one-way or two-way traffic."

On the same page, add the following to the paragraph under Art. 2, Aspect: "except that back-to-back lamp units may not be required for one-way highway traffic."

[The motion was duly seconded, was put to a vote, and carried.]

Chairman Trissal: Mr. Vice President, that concludes the report of Committee 9. I would like to call your attention to the fact that we ran off 5 min of the 10-min late start we got.

Vice President Brown: I am surprised, Mr. Trissal, that you didn't say that was standard IC performance.

Thank you, Mr. Trissal, and your committee, for the information and recommendations which you produce with respect to the ever increasingly important aspects of highway matters as they affect the railroads. And also for the special feature of your program, the very informative talk by Mr. Tallamy.

Your committee is excused with the thanks of the Association. [Applause]

Discussion on Wood Preservation

[For report, see pp. 415–424.]

[Vice President Brown presiding.]

Vice President Brown: Our next committee to report is Committee 17—Wood Preservation, of which P. D. Brentlinger, forester, Pennsylvania Railroad, Philadelphia, is chairman. It will be appreciated if Mr. Brentlinger and the other members of his committee will come to the platform at this time and make their report.

Chairman P. D. Brentlinger: Mr. Brown, the report of Committee 17 has been published, and our presentation here this afternoon is limited to Manual material.

Assignment 1—Revision of Manual.

Chairman Brentlinger: The report on Assignment 1 will be presented by Subcommittee Chairman C. S. Burt, assistant to vice president purchases and stores, Illinois Central Railroad

C. S. Burt: The proposed changes in the Manual we now present for your considertion deal with material in Part 1 of Chapter 17—Wood Preservation.

The first change is on page 17–1–1, last paragraph, last sentence. Our purpose is to extend the use of "steaming" as a conditioner for different species of wood, when the end use requires a particularly dry surface after treatment.

Mr. Chairman, I move the adoption of the revised paragraph covering this matter as outlined in the printed report of this committee.

[The motion was duly seconded, was put to a vote, and carried.]

Page 17–1–3, second paragraph. The revision suggested here is somewhat editorial in that our purpose is to state more clearly that admixtures of creosote and coal tar will generally result in treated wood having somewhat oily surface. Therefore, such solutions are not suitable where clean treatments are required.

Mr. Chairman, I move the adoption of the revised paragraph as shown in our printed report.

[The motion was duly seconded, was put to a vote, and carried.]

Page 17–1–3, third paragraph. The purpose is to include all water borne preservatives in the category of those that are highly toxic, but less permanent than creosote under service conditions, where wood is in contact with water or subject to excessive wetting.

Mr. Chairman, I move the adoption of the revised paragraph as shown in our printed report.

[The motion was duly seconded, was put to a vote, and carried.]

Page 17–1–3, "Plant Practice", reapprove without change.

Mr. Chairman, I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Page 17–1–5, "Records of Treatment and Reports of Inspection." The additions suggested are intended to expand the information required to the end that these records will tell a more complete story.

Mr. Chairman, I move the adoption of the recommendation as outlined in our report.

[The motion was duly seconded, was put to a vote, and carried.]

Page 17–1–6, Par. e of Requisitioning Preservatively Treated Wood. It is proposed to add the new preservatives that have now been accepted as standards by this Association.

Mr. Chairman, I move the adoption of the revised paragraph as proposed in our report.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Chairman, that completes the report on Assignment 1.

Assignment 2—Specifications for Wood Preservatives.

Chairman Brentlinger: The report on Assignment 2 will be presented by Subcommittee Chairman W. W. Barger, chief inspector, Tie and Timber Treating Department, Santa Fe.

W. W. Barger: The report on this assignment is made up of five parts. In four of the five parts, your committee submits recommendations with respect to Chapter 17 of the Manual.

Part 1. The present specification for creosote-coal tar solutions makes no allowance for the decrease in distillate up to 235 deg C in solutions due to treatment operations. Your committee is of the opinion that Note 1 at the bottom of the specifications should be changed to include a minimum allowable distillate of 2.0 percent in used solutions. This would also bring the specifications in line with similar specifications of other Associations.

Mr. Vice President, I move that the footnote at the bottom of the specifications be changed to allow a minimum of 2.0 percent distillate up to 235 deg C in used solutions.

[Thhe motion was duly seconded, was put to a vote, and carried.]

Mr. Barger: Under Part 2 your committee has studied two new preservatives—fluor-chrome-arsenic phenol Type B (Osmosalts) and copperized chromated arsenate (copperized Boliden salts) and recommends the acceptance of these two preservatives as standards to be printed in the Manual.

Mr. Vice President, I move that these two preservatives be adopted as standards and the specifications be published in the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Barger: Under Part 3 your committee has concluded its study on sampling of preservatives and is of the opinion that the AWPA Standard Methods for Sampling Wood Preservatives, A–4, should be accepted as an AREA Standard. These methods of sampling include methods of sampling all types of preservatives.

Mr. Vice President, I move that the AREA Standard Method of Sampling Creosote in Tank Cars, Manual Pages 17–3–5 to 17–3–9, incl., be deleted and reference to AWPA Manual Sec. A–4, "Standard Methods for Sampling Wood Preservatives," be published in the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Barger: Part 4 is concerned with comments following salt preservatives. Your committee has come to definite conclusions on this subject but will hold up final report until 1961 or 1962, at which time revision of the specifications affected will be requested.

Part 5 is concerned with reapproval of present Manual material. There are four standards involved:

Standard Volume Correction Table for Creosote–Petroleum Solutions, Pages 17–3–1 and 17–3–2.

Volume Correction for Temperature in measurement of Creosote, pages 17–3–3 and 17–3–4.

Standard Abridged Volume Correction Tables for Petroleum Oils, pages 17–3–11 and 17–3–12.

Volume Correction Factors for Preservative Salt Solutions, pages 17–3–13 and 17–3–14.

Mr. Vice President, I move that the four standards as read be reapproved without change.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Barger: This concludes the report on Assignment 2.

Chairman Brentlinger: And this concludes the report of Committee 17.

Vice President Brown: Thank you, Mr. Brentlinger. In spite of the fact that we have all long since been sold on the value of effective wood preservation, your com-

mittee continues to have a very important place in the work of our Association. We appreciate the interest which your committee takes in keeping our Manual up to date with respect to preservatives, and in advising us currently with respect to new developments in preservatives and preservative treatments. Mr. Brentlinger, both as chairman of our Committee 3—Ties, from 1952 to 1954, and now as chairman of Committee 17, you have rendered an invaluable service to this Association, for which it is deeply indebted. While it is with a sense of loss that we see you complete your present chairmanship, we are confident that under the direction of R. B. Radkey and W. W. Barger, the work of the committee will go forward in a very satisfactory manner. Thank you again.

You are now excused with the thanks of the Association. [Applause]

Mr. Woolford has left a note here that the subject of prestressed ties will be discussed near the close of this session and he would like to have a large attendance.

Discussion on Ties

[For report, see p. 405–413.]

[Vice President Brown presiding.]

Vice President Brown: The next committee to report is Committee 3 on Ties, of which F. J. Fudge, timber engineer of the New York Central System, is chairman. Will you present your report please.

Chairman F. J. Fudge: Mr. Vice President, members and guests of the Association:

The report of Committee 3 is printed in the December Bulletin, No. 554, beginning on page 405, and in the June–July Bulletin, No. 551, beginning on pages 1, 13 and 135. Before presenting our reports, we would like to report the death of member Ben David Howe, whose memoir is published with our report in Bulletin 554.

Committee 3 has reported on five of its six assignments in the Bulletins. We will summarize three of the reports today.

Assignment 1—Revision of Manual.

Chairman Fudge: The report on Assignment 1 will be presented by Subcommittee Chairman W. E. Fuhr, assistant chief engineer, signals and communications, Milwaukee Railroad.

W. E. Fuhr: Mr. Vice President and members of the AREA:

The following documents in Chapter 3—Ties, are presented for reapproval without change:

Marking Ties to Indicate Size Acceptance, page 3–1–6.
Size of Holes Bored for Spikes, page 3–1–8.
Specifications for Tie Plugs, page 3–1–9.
Specifications for Dating Nails, page 3–1–11.
Specifications for Tie Coatings, page 3–1–14.

Mr. Vice President, I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Fuhr: In conjunction with the presentation of the above Manual material the committee reports, as information, that there is interest being shown in changing the design of tie plugs because of a recently developed plug-driving machine that does not require the plugs to be pointed. Straight-sided sticks are used. Your committee will

investigate and study this topic further, leading to possible specifications to cover tie plugs designed for use in such machines.

Continued study of the Manual material will be carried out during the year and additional recommendations prepared for presentation at the Annual Meeting in 1961.

Assignment 3—Substitutes for Wood Ties.

Chairman Fudge: The report on Assignment 3 will be presented by Subcommittee Chairman M. J. Hubbard, assistant chief engineer system, Chesapeake & Ohio.

M. J. Hubbard: The fundamentals to consider in the design of substitute ties are: fastenings, gage, line, surface, insulation, and cause of failure.

Various types of substitute ties have been tested, both in the laboratory and in the field, since 1910, but the only substitute now being given extensive test is the prestressed concrete tie.

For the past two years the AAR Research Center has been working with the Portland Cement Association and the American Concrete Crosstie Corporation on the most economical design of a prestressed concrete tie, from which they have developed a tie with a 9-in face, 12-in base, and a weight of approximately 580 lb.

The following are some of the advantages and disadvantages of wood and prestressed concrete ties.

1. Life of treated wood is approximately 30 years—expected life of prestressed concrete tie, 50 years.
2. Extra cost would occur in handling and installing 580-lb concrete ties compared with handling approximately 200-lb wood ties.
3. Extra weight of concrete tie helps hold track.
4. Reduction in number ties per mile—3000 wood vs. 2000 concrete.
5. Cost of treated wood ties, $3.50 to $6.09 each—prestressed concrete ties, $9.00 to $11.00.
6. Concrete ties require insulation for track circuits.
7. Wood tie serves as cushion for load impact.

This committee is carefully investigating progress in the development of substitute ties in order to keep up to date and take advantage of any possibilities.

It is not the committee's intention to distract from the good performance of treated wood ties by the title "Substitute for Wood Ties", as the various wood-preserving companies in conjunction with AWPA, Cross Tie Association and AREA Committee 17—Wood Preservation, have been making great strides in extending the service life of wood cross ties, for which all railroads are grateful.

As announced by President Woolford this morning, G. M. Magee, director of engineering research, AAR, will at the conclusion of today's scheduled program give us some of the highlights in design of the prestressed concrete ties, along with slides showing the prestressed concrete ties that were installed during the early part of March in two ¼-mile test sections in main-line track, one installation near Tampa, Fla., on the Seaboard Air Line, and the other between Four Oaks and Benson, S. C., on the Atlantic Coast Line.

[President Woolford resumed the chair.]

President Woolford: Thank you, Mr. Hubbard. Your report will be received as information.

Assignment 4—Tie Renewals and Cost per Mile of Maintained Track.

CHAIRMAN FUDGE: The report on Assignment 4 will be presented by Subcommittee Chairman L. W. Kistler, retired tie and timber agent, Frisco.

L. W. KISTLER: The AAR annual cross tie statistics as compiled by the Bureau of Railway Economics for 1958 are a bit surprising. For, while reduced cross tie insertions were expected, it was hardly anticipated that the Class I Railroads of the United States would renew only 15,231,689 new wood cross ties last year. This was 6,293,544 less than were inserted in 1957, a reduction of over 29 percent, and represents an all-time low in installations of only 47 ties per mile of maintained track.

Reduced density of traffic (earnings) was even more of a dominant factor in this reduction this year than it was last, as equated gross ton miles per mile of track was off 580,000 tons, or 8.82 percent, quite a sizeable decrease.

The following table of comparisons, showing the "Low" region, the "High" region and the United States averages, should be of interest:

	"Low" Region	*"High" Region*	*United States Averages*
Inserted in 1958 — Ties per mile	28 Great Lakes	69 Southern	47
Change 1958 from 1957— Tie insertions per mile	1 More New England	36 Less Pocahontas	20 Less
Average cost per tie	$3.13 Southwestern	$4.06 Central Eastern	$3.69
Tie cost per mile of track	$101 Great Lakes	$263—Southern	$175
Equated gross ton miles per track mile (thousands)	3,952 Northwestern	9,317 Pocahontas	5,996
Average annual insertions per mile—			
5-year average	47.8 New England	90.8 Southwestern	65.8
10-year average	57.0 New England	107.3 Southern	77.9
20-year average	(For United States only)		103.6
Estimated average life based on—			
5-year average	33.57 Southwestern	59.96 New England	45.71
10-year average	28.14 Southern	50.28 New England	38.61
20-year average	(For United States only)		29.03
Number ties per mile used in above calculations	3,048 Southwestern 3,019 Southern	*2,866 New England	3,008

*This is 138 ties less than was shown for the New England region last year and is due to the New York, New Haven and Hartford showing 1,269,904 fewer ties in track with a reduction in mileage of only 15.18 miles. Their ties per mile was reduced from 3,067 to 2,707.

Because of the many variables and other factors involved and since reduced traffic did so vitally affect cross tie insertions last year, interpretation or evaluation of the above statistics is most difficult and not conducive to factual conclusions.

One fact, however, stands out clearly, and that is that the railroads are now benefiting greatly from the many years use of effective wood preservation. For example, in 1927, only 31 years ago, and the first year of these statistics, two railroads having the largest quantities of insertions, renewed over 50 percent as many ties, and five railroads installed more than all the railroads put in last year.

Perhaps the fantastic 40-year average service life of treated wood ties is about to be attained, thus putting further handicaps in the way of substitute ties.

This report is presented as information.

President Woolford: Thank you, Mr. Kistler. It will be entered as information.

Chairman Fudge: Mr. President, this concludes the report of Committee 3.

President Woolford: Thank you, Mr. Fudge. With cross ties still one of the basic and most costly elements of the track structure, we are most fortunate in having had this committee, which has been most prominent since the organization of our Association, to keep us constantly abreast of every aspect affecting the service life of ties. Along with Committee 17, your committee has sponsored practices which have saved the railroads hundreds of millions of dollars over the years. We are glad that your committee does not consider the job done and continues to keep us advised, both with respect to prolonging the life of wood ties, and developments and tests with respect to substitutes for wood ties. We shall continue to look to your committee for the latest developments in both of these fields. May I mention prestressed concrete ties, which are now entering the picture.

Your committee is now excused with the thanks of the Association. [Applause]

C. J. Geyer (C&O, Ret.): Mr. President, may I have the privilege of the floor for just a moment? I desire to pay a compliment and not to condemn. The tie statistics published for over 33 years by the Tie committee, in my opinion, are very useful. I have used them for many things, some of which I am sure were never contemplated by this committee initially. One was to get a very substantial reduction in the price of ties from a joint facility. I commend this form of publishing data to other committees where the table form is adaptable. Thank you.

Chairman Fudge: Thank you, sir. We certainly appreciate your interest.

President Woolford: Thank you, Mr. Geyer. I use it the same way. It is very useful information, and sometimes it helps me when they want to know why I can't get my tie insertions down to where some of the rest of the roads are.

Discussion on Maintenance of Way Work Equipment

[For report see pp. 491–540.]

[President Woolford presiding.]

President Woolford: Turning from materials to equipment, we will now hear the report of Committee 27—Maintenance of Way Work Equipment, the chairman of which is F. L. Horn, engineer of track, Terminal Railroad Association of St. Louis. This committee again has a large number of reports to present, and I shall be glad if it will come to the platform at this time and present its various reports. As you were advised at our Annual Luncheon, Mr. Horn could not be with us today. Accordingly, the report of the committee will be conducted by the vice chairman of the committee, R. S. Radspinner, supervisor roadway machines and equipment, Chesapeake & Ohio, Saginaw, Mich. Mr. Radspinner, I will turn the meeting over to you.

Vice Chairman R. S. Radspinner: Mr. President, members of the Association, and guests:

I certainly regret that Mr. Horn will not be here to present his reports. I am sure he could have done a much better job. I regret the storm that kept him at home did not happen next Tuesday instead of today.

Committee 27 regretfully announces the death on May 23, 1959, of F. H. McKenney, engineer of track, system, of the Burlington Lines. Mr. McKenney had long been one of the more active members of the committee and will be sorely missed. A memoir is included in the report of the committee.

The report of Committee 27 appears in Bulletin 554, pages 491 to 540, incl. We are reporting on nine assignments. Five final reports, two progress reports on continuing assignments, and two brief statements of progress made are included. The normal presentation of these reports by the subcommittee chairmen is being dispensed with in order to provide time for a special feature. However, the subcommittees' remarks will be published in the Proceedings in the usual manner.

Assignment 1—Revision of Manual.

Chapter 27 of the Manual is being reviewed. Material therein will be recommended for reapproval or revision in 1961 and 1962. The chairman of the subcommittee and vice chairman of Committee 27 is R. S. Radspinner, supervisor roadway machines and equipment, Chesapeake & Ohio Railway.

Assignment 1 (a)—Revision of Handbook of Instruction for Care and Operation of Maintenance of Way Equipment.

Instructions for the care and operation of five machines are given. Included are a combination tamper-jack, a spike driver–air, two ballast regulators, and a yard cleaner. All of these machines have sufficient general distribution and use to justify their inclusion in the Handbook. Therefore, it is the recommendation of your committee that this material be included in the next revision of the Handbook.

S. E. Tracy, superintendent of work equipment, Chicago, Burlington and Quincy Railroad served as subcommittee chairman.

Assignment 3—Basis for Replacement of Work Equipment.

A brief statement of progress is offered as information. More time must be devoted to this study in order to fully develop formulas which may be used as a reliable basis for the replacement of work equipment. Information from railroads and large contractors has been obtained and is being analyzed to arrive at the necessary formulas. N. W. Hutchison, engineer of work equipment, Chesapeake & Ohio Railway, is subcommittee chairman.

Assignment 4—Improvements to Be Made to Existing Work Equipment.

This is a progress report, submitted as information, and is a continuation of previous progress reports. Eight machines are included in the report with from two to five improvements offered on each machine. The manufacturers of the machines have been contacted and have advised the committee that they will cooperate so far as possible in effecting the desired improvements. The chairman of the subcommittee handling Assignment 4 is G. L. Zipperion, supervisor of work epuipment, Great Northern Railway.

Assignment 5—Equipment and Supply Cars for Mechanized Gangs.

This is a final report, submitted as information, and supplements previous reports of similar title. Your committee feels that specially equipped rolling stock with rails, loading ramps, blocks, and tie-down devices can greatly benefit the operations of mechanized gangs. Such equipment will minimize manpower required for loading operations, reduce lost time in moving from job site to job site, reduce down time due to damage to equipment in transit, and improve safety of loading and unloading. A number of photographs showing specially equipped cars and other devices in use on the railroad are included in the report. The chairman of the subcommittee is A. C. Danks, Jr., engineer bridges and buildings, Union Railroad.

Assignment 6—Spot Tampers.

This is a final report submitted as information. Three machines designed primarily for spot work are covered. Two of the machines utilize air tamping tools; the third hydraulic tamping tools. There is considerable difference in size, functions, and production among the three machines, factors which should be carefully checked when specifying a machine for purchase.

Your committee felt that one of the most useful items of information for comparison of these machines would be the force of the blow of the tamping tool. The information on the force of the blow of the hydraulic tools was obtained just prior to the filing date of the report and was not fully discussed by the committee. Subsequent discussion brought out that from practical observation the hydraulic tamping tools struck a lighter blow than the heavy air tools on the large air-operated spot tamper, but the numerical value of the force of the blow in foot-pounds was greater for the hydraulic tools. It is believed the method used to measure the force on the tamping blow for the hydraulic tools was not comparable to methods which are standard for the pneumatic tool manufacturers. It is the wish of your committee to retract that portion of the third line of the third paragraph of the report reading "develop 14 ft-lb per blow" until such time as laboratory or field tests can measure the force of the blow of the hydraulic tamping tools by the methods set up by the pneumatic tool industry for tamping tools. This would insure all information on the force of the tamping blow of the various machines being based on the same method of measurement. This information will be made available to the membership.

J. O. Elliott, assistant division engineer, St. Louis–San Francisco Railway is chairman of the subcommittee.

Assignment 7—Use of Hour Meters on Work Equipment.

This is a final report, submitted as information. The types, application and operation of hours meters are discussed. The cost of hour meters is nominal. Their use permits accurate determination of time in operation for scheduling of servicing, for cost or production records, and for a guide to the service life of equipment. Therefore, your committee recommends that hour meters be installed on all larger items of work equipment. The chairman of the subcommittee is C. F. Montague, superintendent maintenance of way equipment, Pennsylvania Railroad.

Assignment 9—Instructions for the Care and Safe Operation of Welding Equipment.

This is a final report submitted as information.

The report covers instructions for all welding and grinding equipment used in welding in maintenance of way departments, both in the field and in shops. Pertinent information was gleaned from many sources in order to make the instructions as complete as possible. Your committee feels that the subcommittee and particularly its chairman have done an outstanding job in this respect.

Reprints of this report, for use by welding personnel in the field or shops, are available from the office of the secretary. Their cost is nominal. Your committee believes that distribution of the report to welding personnel will prove very beneficial to the railroads.

The chairman of the subcommittee that produced these instructions is R. M. Baldock, welding engineer, Norfolk & Western Railway.

Assignment 11—System vs. Division Shop for Maintaining Work Equipment.

This is a final report, submitted as information. The increasing mechanization of maintenance work has required modification of equipment repair facilities. This report is a study of the various shops in use by railroads and discussion of the advantages and disadvantages of each type. No conclusion can be drawn as to the most desirable type of shop for a railroad because of variable conditions. However, shops suitably located and equipped to properly maintain the equipment are essential to the success of mechanized maintenance.

L. B. Waterman, general supervisor work equipment, Baltimore & Ohio Railroad, is chairman of the subcommittee.

Vice Chairman Radspinner: I now wish to introduce the secretary of Committee 27, J. H. Brown, assistant chief engineer, St. Louis–San Francisco Railway.

Panel Discussion on Work Equipment Operators and Mechanics

Vice Chairman Radspinner: Mr. President, members, and guests: In 1958 nine of the leading work equipment manufacturers addressed a letter to then President Ray McBrian with a request for suggestions as to how they, as suppliers, might assist their customers to obtain maximum benefits and economies from the expenditures made for their products.

These manufacturers were concerned with the fact that some of the railroads did not have trained men to operate and maintain their work equipment, resulting in poor operation and maintenance, undue wear and abuse, and excessive down time, all of which prevent maximum production.

A special subcommittee was appointed to meet with representatives of these manufacturers and report back to the general committee. However, it was later decided that it would be of more benefit to both groups if it were presented in the form of a panel discussion. Therefore, we have with us today a panel consisting of five railroad representatives, all from this committee, and five manufacturers' reresentative, to discuss, principally, the matter of training equipment operators and mechanics.

We should like to emphasize to the audience that the gentlemen on this panel are not necessarily expressing their own personal ideas or those of the companies they represent, but rather, the manufacturers' representatives have been chosen, by the suppliers' group, to present the views of the participating industries. The railroad representatives have been chosen by this committee, to present the views of the committee.

I now ask the moderator, R. K. Johnson, superintendent work equipment and reclamation—system, Chesapeake & Ohio Railway, and a past chairman of this committee, to introduce the panel members and proceed with the discussion.

Moderator R. K. Johnson: It is my pleasure to introduce the panel members—Morton S. Westlund, vice president, Jackson Vibrators, Inc.; P. S. Settle, vice president, Railway Maintenance Corp.; Royce Kershaw, president, Kershaw Manufacturing Company; C. H. Johnson, vice president, Fairmont Railway Motors, Inc.; W. B. Blix, manager, Railway Equipment Division, Nordberg Manufacturing Company; Paul Martin, methods engineer, New York Central System; V. W. Oswalt, Sr., superintendent maintenance equipment, Central of Georgia Railway; J. W. Risk, superintendent work equipment, Canadian National Railways; F. L. Etchison, chief engineer, Western Maryland Railway; and G. R. Collier, chief engineer, Gulf, Colorado & Santa Fe Railway.

Now, Mr. Blix, I believe we will open this discussion by asking you what you think is your worst problem in your dealings with the railroads, in connection with the operation of your machines?

Mr. Blix: Our greatest problem is the machine operator. *Our* machines are no better than *your* operator. This applies to quality and quantity performance and, to a very large extent, to loss of time due to breakdown.

Our job of teaching your operators is all too frequently complicated by a constant change in personnel. A serviceman will train an operator for a certain machine, and a week or so later a senior employe bumps him or is awarded the job. Frequently we are asked to train this new man. Then the machine, but not the trained operator, is transferred to a different district and another new man assigned to run it. Sometimes we are asked for additional help, but more frequently no training is given at all, not even a casual reading of our instruction manuals.

This is rough on you and on us. A green operator can do more damage to a machine in a couple of days than a trained operator will experience in a whole working season. He can also harm your track. Our experience has been that requests for emergency service help, as well as "rush" orders for repair parts on account of breakdown, are almost always coincidental with the assignment of new green operators.

We find that the operators and mechanics pay very little attention to instruction manuals and repair parts lists furnished by manufacturers. All too frequently we are asked, "how do you operate your machine to do such and such?" and 99 percent of the time the situation is covered in our operating instructions.

We also receive numerous telephone calls requesting repair parts. The persons calling do not ask for the parts by part number shown in our parts book but try to tell us what it looks like and where it fits in the machine. Sometimes we misunderstand and send the wrong part and this delays repair.

For many years the backbone of good track was a good trackman and a good foreman. Now, with mechanization, the backbone of good track at the lowest possible cost is a good operator, a good mechanic and a good foreman.

Moderator Johnson: Mr. Collier, just what is the operator situation in general on the railroads today? What has been, and what is being done along the line of training operators, and how can we improve the situation?

Mr. Collier: There is no question but that the conditions mentioned by Mr. Blix do exist on certain railroads. The shifting of the operators in the first instance could be eliminated to a great extent if the railroads would establish a separate machine operator's seniority roster and would advertise and assign the position to the senior operator before the new machine is received, and then have this man available for training when the machine is placed in service. In some instances, it may be well to have the service man train another operator at the same time he is training the assigned operator.

There is no question but that some of the railroads have no set training program for operators. There are a lot of things that bring this about and that must be given consideration; such as, part-time employment, seniority, labor agreements, and rules which restrict the selection of men to be trained. However, some railroads have an operators' trainee program. Some of the railroads now have a provision in their agreement covering operator trainees which provides that the trainee be given a trial period. If he does not show the proper aptitude he is not trained, but is returned to the roster from which he came. If he has the aptitude, he is trained on a variety of machines, small to large, and not given operator seniority until he has completed his training. Some railroads give a written test to operators and some have an operator instructor who travels around over the railroad, training and qualifying operators for a number of machines.

It is the responsibility of a railroad to train its operators. After all, the machine, during its life, may be operated by 40 or 50 or more operators. Where a machine is transferred from one territory to the other, a trained operator could be shifted, along with the machine, to train the new operator.

When a machine is in the shop for seasonal repairs, the operator should go along with the machine and assist in such repairs, thus becoming more familiar with the working parts of the machine.

Several suggestions, including that of an operator trainee program, were recommended by Committee 27 and outlined in the 1952 Proceedings.

If these recommendations are followed, in part or as a whole, the operator situation will improve, and with this improvement there will be an increase in production and a decrease in maintenance costs. The railroads, in general, should take a close look at this situation.

Moderator Johnson: We would now like Mr. Johnson, if he will, please, to express some of his thoughts regarding machine operators.

C. H. Johnson: Mr. Moderator, we are particularly interested in the point Mr. Collier makes about production, as well as the matter of abuse brought out by Mr. Blix. We believe that most manufacturers' problems parallel those that Mr. Blix outlined insofar as operators are concerned.

A poor operator, operating a single machine in an operation where only one machine is required for the particular job, will not get full production. Also, this same poor operator handling a given machine where a group of machines are used in sequence, will not only fail to get full production from his machine but he also prevents the other operators working with him from securing full production from their units, consequently reducing the production of the entire force.

On some railroads a laborer is assigned to a machine and taught to operate it. This may be a machine that required little skill; however, this laborer immediately is placed on the operators' roster, then and without further training, he is placed on other machines that are more complicated and require more skill, and again the result is lower production. We are certain that the loss of productive time, as well as the cost of repairs due to neglect and abuse of a machine, must amount to quite a sum of money in a year's time.

It is the objective of manufacturers to continually bring out new machines and improve existing machines so that production will be improved and maintenance cost of machines reduced. We believe that to get the greatest benefit from these improvements the railroads must have trained and qualified operators. Where one operator trains another man to operate a given machine, it works out all right in some cases if the operator doing the training is a good one. However, if he is a poor operator he teaches the trainee all of his bad habits and you get another poor operator; then the second man teaches a third man, and you end up with additional poor operators. Therefore, we believe that extreme care should be exercised in selecting the operator and in particular an operator who is to give training to others.

Moderator Johnson: Mr. Martin, I believe you have something worthwhile to say on the subject of training operators.

Mr. Martin: Based upon the remarks made by these gentlemen, it appears to be the concensus that the skill of a machine operator is quite important if the railroads are to achieve the maximum return on the money invested in their work equipment. I think we will all agree that the annual output of any unit of work equipment is more de-

pendent upon the skill, competence, and interest of the operator than upon any other single factor, and it would seem entirely absurd to place an inexperienced operator on a high-priced machine who, through just one false move, could cause serious damage to it, resulting in a heavy repair bill and loss of production time. On the other hand, a skilled operator, who is familiar with his machine, has the "know how" to get the last ounce of production from it, with the least amount of wear and tear.

We talk about the manufacturers' service men training the railroads' employees which, in the case of a new type of machine, is a definite necessity. However, there is considerably more to training an operator than just showing him what controls he must manipulate in order to make the machine move. An operator must also learn how to get the maximum number of units of high quality work from the machine; how, where, and when to lubricate it with the correct oils and greases; how to make running repairs and adjustments to keep the machine running without having to frequently call for a mechanic; how to inspect it periodically as a matter of preventive maintenance; and what must be done to protect it from damage when it is to be idle. He must also have impressed upon him the necessity for paying strict attention to his work while operating a machine; that it must be shut down immediately when a breakdown appears imminent; that it must be kept clean; and finally the matter of keeping required records.

While we may and do expect the manufacturers to partially train an operator for a new type of machine, it is, as stated by one of my panel colleagues, the responsibility of the railroads to give their operators the complete training necessary to produce the greatest net benefits. It is the belief of the men on one railroad I know of, that the most profitable and effective medium for training operators is that of a supervisory position carrying the title of "operator instructor." The background of the man, chosen for this position, should include past experience as a skilled operator on a variety of machines, a thorough knowledge of the mechanics of the machines and the ability to impart his knowledge to others. His function is not only to thoroughly train operators but to keep an eye on them after they are trained, with the objective of increasing their skill and their worth to the company. He also is the final authority as to whether a man is qualified and to be included on the roster. The investment in such a position will more than pay off by increasing production and by decreasing the down time and heavy repair bills.

Moderator Johnson: Mr. Etchison, what is your thinking as to what could be done to improve this situation?

Mr. Etchison: Certain railroads now send work equipment supervisors and mechanics to training schools that are conducted at the plants of certain manufacturers, such as Caterpillar Tractor, General Motors Diesel and Vickers Hydraulic Company, to name a few. Some of these same personnel are sent to the schools, for a day or so, that are conducted by various engine manufacturers located in the vicinity of some railroads.

Jackson Vibrators, Inc., has, for several years, held training schools at Ludington, Mich., which covers their tampers and other auxiliary equipment, to which some railroads have sent their work equipment supervisory and other personnel.

In general, I believe, the situation could be improved if the manufacturers were to set up training schools, preferably during the winter, at their plants, to instruct supervisors and mechanics in the maintenance and repair of their work equipment products. The railroads, I believe, would take advantage of this opportunity by having as many of their work equipment personnel as possible attend if given advanced scheduling for such schools, so that plenty of time can be had for lining up personnel who could be away at such times. I also think there should be more frequent visits of the manufacturers' representatives to the railroads, where, at certain locations, the railroad could

assemble groups of its operators and mechanics, along with supervision, so that the manufacturer's representative could lecture upon the care and operation, etc., of their equipment, illustrating with movies or slides, the points they desire to bring out. Also, of course, being prepared for a question and answer period and a general discussion. I am sure, if the railroads take the initiative in this, the manufacturers would cooperate wholeheartedly, if given sufficient advance notice.

Moderator Johnson: Mr. Westlund, since Mr. Etchison has mentioned that your company conducts schools at your plant, perhaps you would like to comment on this subject.

Mr. Westlund: In recent years, it has been increasingly difficult for us, through the medium of our field engineers, to secure enough of the working time of railroad men concerned with the maintenance of work equipment, for reasons that are apparent to all present. This situation applied equally to railroad supervisory, field and shop personnel.

It was felt that training courses held at the factory might be at least a partial solution of the problem. Accordingly, beginning in January 1958, we instituted and have since conducted several school sessions from late autumn to early spring, annually. We did this with two objectives in mind. No. 1: To assist the railroads in securing for personnel concerned a better understanding of what is required for the proper use, operation and care of Jackson machines. No. 2: To free our district field engineers of a part of this load that they might better serve all customers in their respective territories.

Thirty-nine railroads have sent 225 students to these sessions over the period ending in March 1960.

If we may judge from comments of attending railroad personnel and official expressions, these schools have been of assistance to our customers. In several cases, we have had repeat attendance because of the need to secure information about new machines. We have benefited similarly, generally speaking. In particular, our field men have gained a more equitable distribution of their time for all users. We feel that the schools are a very effective supplement to our field training.

To further augment the training given on the job by our district field engineers, we are glad to have them participate in schools or training classes conducted by our customers, and, to such schools, we will also send factory personnel to assist as may be indicated.

Moderator Johnson: We would now like to have Mr. Settle tell us, if he will, what the manufacturers' worst problem is in dealing with work equipment mechanics.

Mr. Settle: The day of having a "handy man" as a machine repairman is past. Because a man is a good machinist or a good automobile mechanic does not necessarily mean that he is good at repairing track machinery. The work equipment mechanic should be able to operate the machine because he is then in a better position to know where to look for trouble. We feel that some of the best mechanics come from the operators' ranks.

The mechanic situation and the operator situation vary from one railroad to another. Some railroads have no mechanics at all and depend, in the main, upon the operators to make repairs in the field; some have no method of training either operators or mechanics, and this results in minimum production, breakdowns, costly delays, and repairs. Our greatest trouble lies with mechanics who not only cannot operate the machine but have never overhauled or repaired it and do not know where to look for the trouble. Usually where you find good mechanics who have been trained to operate the machines, you also find good operators.

Our service men endeavor to teach the mechanic as much as we can at the time we break in the operator. This takes several days; however, in a lot of instances, the mechanic does not stay with our service men long enough to become as familiar as he should with our machine. In a lot of other cases some of the men have not had sufficient experience or training to be good mechanics.

MODERATOR JOHNSON: Mr. Risk, would you care to comment upon the remarks made by Mr. Settle?

MR. RISK: I am heartily in favor of the manufacturers' and railroad schooling; however, we must not lose sight of the fact that the best schooling that a mechanic or operator can get is on the railroad—in the shop and in the field—and it is up to the railroad to train and qualify them.

There are two types of mechanics involved: the mechanics assigned to the work equipment shops and the mechanics assigned to field work. In general, it can be said that a field mechanic is better with some shop experience, and a shop mechanic is better if he has had some field experience; however, shop experience is of greater benefit to a field mechanic if he has completely repaired a machine in the shop, and is thus in a better position to maintain the machine in the field.

Special attention can be given to shop mechanics who express a desire to become field mechanics. These men can work on as many machines as possible, moving from one type of machine to another to get varied experience. A man in the shop who has no desire to become a field mechanic can be used upon one type of work almost continuously.

One railroad has agreement rules whereby a man, to become a work equipment mechanic, is given a six months' probation period as a trainee. If he does not show the right aptitude he then is released back to the job he came from, if from the operators' or other roster. If he shows the right aptitude he then goes through a training period of four years as an assistant mechanic in the work equipment shop and in the field before he becomes a qualified mechanic. With this method, some excellent work equipment mechanics will be produced.

On some railroads, the work equipment shops are not under the jurisdiction of the maintenance of way or engineering departments; while the field repair work is performed by maintenance of way men. One training method is to take a machinist who has little or no work equipment experience and team him up with an experienced work equipment mechanic in the shop and have the experienced man teach the new man. This is about the only way you can produce work equipment mechanics under certain rules which now obtain on some railroads.

The railroads have many good mechanics who have come from the operators' ranks. They also have many from other sources. There are, no doubt, some mechanics who have not been properly trained. Here again, we have, as in the case of operators, certain restrictions in selecting the men we wish to have as field mechanics. We find that a good automobile mechanic does not necessarily make a good work equipment mechanic. Of course, they can become good mechanics on track machines and other work equipment, with proper training. A field mechanic on a railroad today must be familiar with all types of machines. He may have one or more power tampers on his territory, and at the same time, a number of automotive vehicles, shovels, cranes, tractors, dozers, etc.

In its published Proceedings of 1955, Committee 27 recommended that the railroads set up a training program for mechanics. Some of the railroads have a working agreement with the labor organization whereby men are trained in the field and in the shop; some of them coming from the operators' ranks. This agreement also provides that the work equipment operators can work in the shop during the off season and assist the shop mechanics in the repairs to his or any other machine.

There is no doubt that in certain instances the railroads have been lax and have made little effort to work out this problem, so as to insure that their mechanics are properly trained.

MODERATOR JOHNSON: Mr. Oswalt, you have had a lot of experience in the field of work equipment. Will you please favor us with some of your thoughts as to how the situation we have been talking about can be improved.

MR. OSWALT: This discussion has, so far, centered mostly around a service man visiting a railroad when a new machine is placed in service, and training the operator at that time. This is all well and good but it is only the beginning. I would like to suggest that the manufacturers have their service representatives make periodic visits to the machines in the field during the regular working season; also have their service men visit the railroad work equipment shops while the machines are being overhauled during the off season. It would possibly be best for the service man, during his periodic visits, to call on the superintendent or supervisor in charge of work equipment so the latter may have a chance to air his troubles and discuss the best methods of preventing equipment failures. The work equipment manufacturers benefit by this procedure as well as the railroad. While the service man is teaching the work equipment forces about the repairs to the machines involved, either in the shop or in the field, the service man will pick up some ideas from these mechanics or operators as to how to reduce wear, as well as learn about some of the weak points in the machines. Many of the improvements that are made to existing machines are suggested by railroad people.

The service man is the railroad work equipment departments' contact with the machine manufacturers. A lot of times his knowledge and experience is what sells the next machine of the type he is servicing. To us, he is the backbone of the manufacturers' organization, since he must be able to operate the machine, as well as repair it, and be able to teach these functions to the operators, and to the field and shop mechanics.

More service calls are needed. The service man should visit oftener and stay longer. It seems to me that, in some instances, the service men are spread pretty thin.

Now as to the machine operators manuals and parts lists: There is no doubt that, in the past, there have been many occasions where the part number has not been given to the manufacturers, and the manual not referred to, and this still occurs in some cases. The manuals and parts books furnished recently are an improvement over those furnished in the past; however, there is still room for improvement. Some of the parts books and manuals furnished are still somewhat confusing to the average operator, and to some of the mechanics. In addition to simple step-by-step operating instructions, they should include definite recommendations as to the greases and oils and wire rope to be used. They should also include electrical and hydraulic circuit diagrams. An example of the type desired is Caterpillars' "Service Men's Reference Book."

Parts books should be in sufficient detail and should be furnished along with the machine instead of months later. When a machine has been modified, a revised parts list should be furnished immediately.

Again I would like to emphasize the need for more service calls, so that the service men can follow up all of the machines—not just the new ones. The machine that is a few years old is as important to the railroads as the one just purchased.

MODERATOR JOHNSON: Mr. Kershaw, you have heard the "pros and cons" on the subject at hand. From your wealth of experience, we would like you to comment on the subject generally.

MR. KERSHAW: We find that the operators and mechanics vary greatly from one railroad to another; some good and some bad. Where the railroad managements insist

on good operators, good mechanics, and well-maintained machines, they get these things. Where they do not insist upon them, they have poor mechanics, poor operators and poorly maintained machines.

The problems of training an operator or a mechanic are similar to those we manufacturers encounter in trying to produce good service men. We probably have less stringent agreement rules, which gives us a chance to select the men more carefully.

They all have shop experience and are thoroughly familiar with the machines they are to service. They, of course, must be expert operators. I think any railroad work equipment mechanic should be able to operate the machines that he must maintain. You really have to know how a machine should behave when it is running properly, in order to know what is functioning improperly, in case of trouble, and what is probably causing this trouble. A mechanic or an operator who is familiar with the operation can feel when something is wrong with the machine. I agree with what has been said about the service men learning something from his visits to the work equipment shops and the field where the machines are being used. This field work by our service men, under actual operating conditions on the track, is where they get real experience, which enables us to further develop and improve our machines; also the experiences they gain on one railroad which is of benefit can be passed on to other railroads.

I think the idea of schools or schooling is fine, but as has been said, the best place to train mechanics is on the railroad—out on the line, or in the work equipment shops.

The manufacturers all have good service men and they do make an earnest endeavor to visit the railroads, both in the shop and in the field. Sometimes they are spread pretty thin because of the way we must use them. They are sent, many times, to correct some minor condition that could be taken care of in a few minutes by a good operator or a good mechanic. So you see, good operators and mechanics will give our men more time to train your people; also those service men lose a lot of time when placing a new machine in service or finding a machine that is in trouble. We will be told that a machine is to be placed in service at Podunk on the 15th. We send the service man to Podunk, only to find that the machine is at Tank Stop, on another district, in another state, a couple of hundred miles away, and will not be placed in service or unloaded, until next week. If some of the calls of this kind could be eliminated, our regular service calls could be increased.

We have come a long way in the past few years in mechanization of track work. The situation as to service from the manufacturers, and with respect to the operation and maintenance of the machines on the railroads has improved greatly in the past few years, and must continue to improve.

Moderator Johnson: To sum up, it appears that manufacturers want the work equipment people to make better use of the manufacturers' operating manuals and repair parts list. The railroad panel members say that the manuals and parts list now furnished are not in sufficient detail and are confusing, and that they should be patterned after manuals and parts list that are furnished by certain other manufacturers.

The railroad panel members want better service—more service calls—and say the service men are spread too thin. The manufacturer panel members want better use made of the service men. The present methods some of the railroads use are the reasons these service men are spread too thin. The panel is in accord that training and schooling of operators and mechanics are necessary, both by the railroads and the work equipment manufacturers.

I should like to point out, as one or more of our committee members on this panel have mentioned, that this committee has, from time to time, in its report, in anticipation

of the steps that the supplier group has taken, made recommendations as to what might be done in the way of improving the procedure for training operators and mechanics, one of which was the use of an operator instructor.

I should like to also call attention to the fact, as one of the panel members pointed out, that since mechanization, the backbone of good track is no longer a good foreman and a good track man, but rather a good operator, a good mechanic, and a good foreman. Another member has pointed out that, where management insists upon good operators and mechanics, they get them.

The railroads today have millions of dollars invested in roadway machines and work equipment. In order to get a full return on this huge investment they must get full production from their machines. They cannot afford to have poor operators or mechanics. Competent operators and mechanics will reduce down-time, abuse of machines, and costly repairs, as well as insure maximum production.

It has been stated that it is the responsibility of the railroads to train the operators and mechanics.

Some railroads, despite the difficulties which they encounter in doing so, have set up workable and comprehensive training programs for operators and mechanics. So, we feel that some progress has been made, but there is still much to be done.

Mr. President, this concludes the formal presentation of our panel discussion, and I should like to personally express to these gentlemen my personal appreciation, as well as that of the committee, for contributing so much time and effort to make it a success. If there is time for questions from the floor, I or one of the panel members, will do our best to answer them.

Vice Chairman Radspinner: Are there any questions from the floor?

President Woolford: If I were out in the audience, I think I could take some "pot shots" at this panel, and I think you can, too.

J. M. Giles (Caterpillar Tractor Company): I can't afford to do that because they would shoot back. I was trained under one of the best maintenance men in existence. The company would buy a machine and the fellows would stand around looking at it and somebody would say, "Isn't that a pretty thing?"

The boss would say, "We bought it to work, not to be admired."

I have always taken that to heart. We buy a machine to work and not to admire.

Mr. Etchison was kind enough to mention our company's school which we have for railroad people at our plant. But, I take issue with his statement that it should be held in the winter. I canvassed 14 different railroads and I never could get any of them to agree to that. You have your own shop work to do in the winter and it is the people in the shop that we want to bring in—not the nut and bolt man, you understand, the guy that uses a wrench—but the supervisors who can take back to their railroads the fundamental things that we think they need to know to maintain our equipment.

And, as far as sending our mechanics out on the job, as Mr. Kershaw mentioned, we are one of the fortunate organizations. We have over 116 agencies domestically, and we are equipped to give service.

Now, the personnel has changed in the past 30 years, as we all know. We are employing young fellows who in a lot of cases have had audio-visual training in the Army, and I think the solution to this thing is for supervision to get these men together and give them this education, and they will know what to do. Thank you for your time.

Vice Chairman Radspinner: Thank you very much, Mr. Johnson, and members of the panel. The preparation of this discussion required a great deal of time and effort on

the part of all participants, especially Mr. Johnson, and I wish to express the thanks of Committee 27 to everyone who participated.

President Woolford: Thank you, Mr. Radspinner, for another series of interesting and informative reports from your committee. Without the extensive mechanization of maintenance of way and structures operations which has taken place during the past 15 to 20 years, at a constantly accelerating pace, the cost of adequately maintaining our properties, if they could be maintained adequately at all, would have been prohibitive costwise. Your committee has had a large part in bringing about this mechanization of our operations and, in the large part, the railroads look to this committee to keep them abreast of all further developments.

And thanks to you, Mr. Johnson, and the members of your panel, for the interesting, frank, and enlightening discussion on the training of work equipment operators and mechanics. This, as we all know, is a real problem which must be faced cooperatively by both the railroads and the manufacturers if we are to secure the greatest return on our huge investment in work equipment. I hope that both Committee 27 and you manufacturers will keep pounding away at this subject with your respective managements and personnel until the shortcomings mentioned in your discussion have been overcome.

Members, you will have to excuse me for not asking you for further participation in the way of floor discussion. I know we could discuss this subject for two or three hours. We just don't have enough time in 2½ days to go further into this most important subject. This panel did well in their discussion of it, but I think they hit it from just one angle. I think there are many other angles that it could be approached from. If I were out in the audience, I might want to get into some argument about it but I think we will have to wind up this discussion if we ever hope to get out of here this afternoon.

Royce Kershaw: I am sure the manufacturers will be glad to hear any questions asked them in their suites after the meeting.

President Woolford: Thank you again. Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Economics of Railway Labor

[For report, see pp. 435–459.]

[President Woolford presiding.]

President Woolford: Important as it is to have the proper power tools and machines, trained operators and mechanics, all of this would be of little avail if our maintenance programs and working organizations were not properly geared to make the most effective and economical use of this equipment. That's where our next committee comes into this picture in a very big way—Committee 22—Economics of Railway Labor, which deals largely with the economies and higher standards of work which can be effected through the use of work equipment and power tools. I shall be pleased if members of this committee will come to the platform and present their report. The chairman of this committee is L. A. Loggins, chief engineer, Southern Pacific Lines in Texas and Louisiana. Mr. Loggins, I am pleased to turn the meeting over to you.

Chairman L. A. Loggins: Mr. President, members and guests:

The report of Committee 22, Economics of Railway Labor, appears in Bulletin 554, pages 435 to 459, incl. We will report on eight assignments. These reports have been condensed and streamlined to conserve time here.

First, we want to pay tribute to three members of our committee who have passed away.

R. A. Gravelle, engineer maintenance of way, Grand Trunk Western Railroad, passed away June 20, 1959. A memoir to Mr. Gravelle appears in Bulletin 554.

R. J. Gammie, retired chief engineer, Texas & Pacific Railway, Dallas, Tex., and a Member Emeritus of Committee 22, passed away on October 19, 1959. A memoir to Mr. Gammie will be prepared by Committee 22 and will appear in the 1960 Proceedings.

J. S. McBride, retired chief engineer of the Chicago & Eastern Illinois Railroad, and a Member Emeritus of Committee 22, passed away at his home in Chicago on December 9, 1959. A memoir to Mr. McBride has been prepared by Committee 22 and will appear in the 1960 Proceedings.

MEMOIR

John Scott McBride

John Scott McBride, Member Emeritus of Committee 22—Economics of Railway Labor, past chairman of that committee, and past director of the AREA, died December 9, 1959.

Mr. McBride was born on November 4, 1880 at Louisville, Ky., the son of James and Emma (Scott) McBride. He was graduated with the degree of Bachelor of Science in civil engineering from Rose Polytechnic Institute in 1905, where he was active in athletics, playing on the football team three years.

He started his railroad engineering career with the Chicago & Eastern Illinois Railroad immediately upon graduation and devoted his entire career to that railroad, advancing through various positions from instrumentman, resident engineer, assistant engineer, valuation engineer, principal assistant engineer, engineer construction and maintenance to chief engineer—consultant. He was a recognized authority on railroad valuation and served on valuation survey committees for the Government and for the AAR, being secretary, 1917–1920, and chairman, 1920–1932, of the Pittsburgh–Chicago District, President's Conference Committee on Valuation.

Mr. McBride joined the American Railway Engineering Association in 1913 and was a member of Committees 2—Ballast, 21—Economics of Railway Operation, and 23—Shops and Locomotive Terminals, as well as Committee 22. He became vice chairman of Committee 22 in 1944, chairman in 1946 and was elected Member Emeritus in 1953.

Mr. McBride, enthusiastically active in Association affairs, had strong opinions and expressed them in a deep resonant bass voice that commanded attention. His ideas were sound and were respected. His standing among his Association colleagues is well attested by the fact that he was elected a director of the Association (in 1946). He had a keen sense of humor and was kind and friendly.

He was a religious man of high principles and positive ideas of gentlemanly conduct and was a regular attendant at St. Philip Neri Roman Catholic Church.

An avid reader, he will be missed at the local branch public library near his home. An ardent golfer, he played right up to the time of his death. He was a long-time member of the South Shore Country Club.

He married Hazel Jennings (a niece of William Jennings Bryan) October 22, 1914. Mrs. McBride preceded him in death on January 1, 1959. Mr. and Mrs. McBride had no children and there are no close family survivors. He died at his home in Chicago a month after his 79th birthday.

Mr. McBride retired as chief engineer—consultant of the Chicago & Eastern Illinois on December 1, 1949. He enjoyed ten years of retirement.

Aside from his outstanding career as a valuation engineer he was proud of the railroad yards at Salem and at Wansford near Evansville which were built under his direction.

His wise counsel has been of immeasurable benefit to Committee 22, and his distinguished service will be remembered with gratitude.

G. M. O'Rourke, *Chairman,*
E. J. Brown,
H. E. Kirby,
Committee on Memoir.

MEMOIR

Robert James Gammie

Robert James Gammie, Member Emeritus and past chairman of Committee 22—Economics of Railway Labor, died on October 19, 1959.

Mr. Gammie, son of James and Lois Gammie, was born October 12, 1889, at Arkansas City, Kans. He graduated from Oklahoma A&M in 1910 with a Bachelor of Science degree in Civil Engineering and entered railroad service as a rodman for the Kansas City Southern Railway. After a brief experience in the contracting business, he worked for the Texas & Pacific Railway until World War I, during which he served as a first lieutenant in the United States Army Corps of Engineers. After the war he returned to the Texas & Pacific and served in various capacities in the engineering and maintenance of way department until 1941 when he was made chief engineer, the position he held until he retired in 1957.

Mr. Gammie joined the AREA in 1916 and became a Life Member in 1951. He served as a director from 1951 to 1953, was chairman of Committee 22 from 1952 to 1954 and was elected Member Emeritus of this committee August 7, 1959. He was a member of Committee 27 from 1931 to 1935 and of the Special Committee on Continuous Welded Rail, 1952 until the time of his death.

Mr. Gammie was a member of the American Society of Civil Engineers, a member of the National Society of Professional Engineers, the Texas Society of Professional Engineers, a 32nd Degree Mason and a Shriner.

Mr. Gammie married Georgia William Talley on August 12, 1915. He was a member of the Episcopal Church and was a man of fine Christian character who had the loyal support of all his subordinates. He was respected and admired by all who knew him.

His wise and steady counsel has helped many young engineers and has been a great influence in Committee 22.

L. A. Loggins, *Chairman,*
J. E. Eisemann,
C. G. Davis,
Committee on Memoir.

Assignment 1—Revision of Manual.

Chairman Loggins: Assignment 1 is under the able direction of Subcommittee Chairman W. W. Hay, professor of railway civil engineering, University of Illinois. Professor Hay has canvassed the railroads for information, and a report will be made at the next meeting. At this time I would like to recognize Professor Hay.

Assignment 2—Analysis of Operations of Railways that Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work.

CHAIRMAN LOGGINS: The report on Assignment 2 will be given by Subcommittee Chairman J. S. Snyder, assistant regional engineer, Pennsylvania Railroad.

J. S. SNYDER: Mr. President, members of the AREA, and guests:

Your committee had the pleasure of visiting the property of the Southern Railway at Atlanta, Ga., during the past year, where we inspected the maintenance of way rail welding and cropping plant, the track panel assembly plant, the turnout prefabricating plant, the modern one-spot car repair shop, and the new Inman classification yard.

The Southern Railway System centralizes its continuous welded rail operations and the rehabilitation of relay rail at its Atlanta plant. New rail received from the mill is unloaded from cars and placed in storage piles by an overhead crane equipped with an electric magnet. When scheduled for welding, the rail is placed on a continuous interlocked conveyor system which conveys it automatically to the electric-flash butt-welding machines, in which the rail is welded into strings 1440 ft long. After inspection the welded strings of rail are placed in storage racks with a capacity of two train loads of rail.

Specially equipped trains, each consisting of 33 cars and a rail unloading machine, transport the rail to the site for installation and later the same train loads continuous strings of bolted relay rail and returns them to the plant for rehabilitation. Relay rail returned to the plant is unloaded, cropped and classified by means of automatic conveyors and is welded similar to new rail for installation on branch lines, or it may be conveyed in conventional lengths to the track panel assembly plant and the prefabricating turnout plant. All operations for handling rail are controlled from an elevated control house located in the center of the plant. The complete operation is an ingenious, ultramodern application of conveyor systems and automatic controls to the process of fabricating continuous welded rail.

This road constructs all track for yards, branch-line track and industrial sidings at the Atlanta plant by assembling track materials into finished panels of track with opposite joints and of conventional lengths. The track panels are loaded into specially equipped cars and transported to the site where they are unloaded and assembled in their permanent location. Each car has a self-contained power plant and automatic controls for handling the track panels, and each train is equipped with a track-laying device to place the panels into position. Semi-trailers are equipped for handling track panels to sites close to the Atlanta plant.

The track panel assembly is performed on a continuous conveyor line of parallel drag chains with movement passing fixed work stations. There are twelve separate and distinct operations in the track assembly operation performed at five work stations on the assembly line. The material handling of stock to the work stations is mechanical, and some features are automatic or semi-automatic.

All turnouts on the Southern are prefabricated at Atlanta and transported to the site of installation on special cars so constructed that the switch end of the turnout, including the 9-ft ties, are loaded on one car in a flat position, and the remainder of the turnout is loaded on the second car in an angular position. The floor of the second car is so constructed that after the frog end of the turnout has been loaded it can be rotated to an angle of 50 deg to give proper balance while being handled in revenue trains. The floors of both cars can be elevated and end tilted so that the turnout can be easily unloaded from one end of the car and the old turnout loaded in the same manner. When the cars are spotted at the site of installation the new turnout can be installed and the

old one loaded on the same cars in a short period of time. This work is accomplished with a tractor-mounted front-end loader equipped with a power winch.

The plant for prefabricating turnouts consists of a concrete bed on which an adjustabel switch pattern is positioned for fabricating various turnout sizes from No. 6 to No. 12. The material for the construction of the turnouts is stored within range of an overhead 15-ton crane which places the material into position for assembly. The small track materials are positioned by hand, and power tools are used to assemble the turnout. The overhead crane loads the turnout on the cars.

The one-spot car repair system, designed by the Southern and installed at Atlanta, provides three locations for repairing cars simultaneously. Two locations are used for light repairs, and the third is used for cars requiring heavier repairs. The cars are moved from the inbound tracks to the work spot by mechanical car-pulling systems controlled by the car repairman at his work station. When the car is spotted in the repair area the repairman is fully equipped to make the necessary repairs. He is provided with hydraulic stationary jacks built into the floor, power-operated jib cranes, overhead reels on each side of car for air, oil and water hoses, and electric welding equipment and oxyacetelyne cutting equipment. Material for car repairs is delivered to the work station by fork lift truck from the storeroom area. Each repair track is interlocked with power-operated blue flag gates and derails controlled by the car repairman from his work station. Adjacent to the car repair building, a one-spot car-cleaning track is provided to accommodate 20 cars at one time. The cars are positioned by a mechanical car mover, and all controls are interlocked and operated by the car cleaner from his work station. He is equipped with modern devices for cleaning and washing cars and the means to dispose of the waste.

The committee also had an opportunity to inspect the Southern's recently completed ultra-modern Inman classification yard. The receiving and departure yard each consists of 16 tracks with an average length of 150 cars each. The classification yard has 65 tracks each with an average length of 45 cars. Over this whole area there are strung innumerable mercury-vapor lights which provide a shadowless yard at night. The yard is equipped with many modern devices, including closed television circuits for reporting car numbers of incoming trains, pneumatic conveyor systems for handling messages and waybills, radio communications with all yard crews, and microfilm cameras to record all waybills.

The Southern Railway System has developed an extensive research laboratory in work simplification methods. In the maintenance of way department remarkable progress has been made by the use of special tools and material-handling devices in its repair and renewal programs. It is the committee's opinion that the Southern Railway has made outstanding progress in reducing its cost of maintenance of way work and at the same time provided its workmen with the best tools to do their work with a minimum amount of physical effort.

Committee 22 again thanks the officers of the Southern Railway for making it possible to inspect its operations at Atlanta.

President Woolford: Thank you, Mr. Snyder. Your report will be accepted as information.

Mr. Loggins, might I remind you, in presenting these reports, that the time is getting pretty short.

Assignment 3—Relative Economies To Be Derived from Ownership Vs. Rental of Maintenance of Way Machinery, Collaborating with Committee 27.

CHAIRMAN LOGGINS: The report on Assignment 3 will be presented by Subcommittee Chairman E. J. Sierleja, supervisor—methods and cost control, Pennsylvania Railroad.

E. J. SIERLEJA: Mr. President, members, and guests:

It is not possible to state an overall economic advantage for either rental or ownership. Each of the true advantages and disadvantages of leasing as listed in this report should be considered and evaluated by the individual railroad, with consideration being given to its own economic situation and the terms of the proposed lease. However, it is believed that the advantage which is most important and which should determine the decision in most cases is that a lease makes possible the use of cost-cutting equipment even though cash is not available.

The type of rental which is considered in this report is one which, in effect, provides a financing tool for purchase of equipment. Because of this fact, and that the available financing charges cover a broad range, the financial department of a railroad should participate in the decision to rent or buy. If a decision is made to rent, then the financial department is in the best position to negotiate for the lowest possible financing charges.

The lease terms determine whether the Internal Revenue Service will allow deductions of the rental payments as an operating expense. If a tax advantage is desired, terms of the proposed lease should be reviewed by the tax department of the railroad to determine whether the lease will be accepted by the I.R.B.

Your committee submits this report as information, with the recommendation that the subject be discontinued.

PRESIDENT WOOLFORD: Thank you, Mr. Sierleja. Your report will be so accepted.

Assignment 4—Labor Economies to be Derived From the Use of Modern Equipment, Optimum Treating Programs and the Most Efficient Chemicals for Control of Vegetation.

CHAIRMAN LOGGINS: The work on Assignment 4 is being progressed under the direction of Subcommittee Chairman H. E. Wilson, assistant chief engineer—system, Atchison, Topeka & Santa Fe Railway, Chicago, who is canvassing the railroads for information which will be assembled and analyzed. A progress report will be made at the next meeting. I want to recognize Mr. Wilson.

Assignment 5—Labor Economies to be Effected Through Use of Power Tools and Mechanized Equipment by Bridge and Building Gangs.

CHAIRMAN LOGGINS: The report on Assignment 4 will be given by Subcommittee Chairman W. E. Chapman, chief engineer—maintenance, Central of Georgia Railway. Mr. Chapman.

W. E. CHAPMAN: Your committee presents a report on a rail—rubber-mounted pile driver outfit, consisting of a large gasoline-operated truck crane mounted on a specially designed crane carrier. The unit is supplied with a 30-ft boom with additional removable sections for a total length of 50 ft.

Telescoping pipe safety boom stops are provided for all booms to prevent over hoisting the boom, and to prevent the boom from going over backwards in the event of the failure of a hoisting line or some part of the hoisting tackle.

Inner dual rear wheels are dished to allow bolting on four additional wheels for highway travel. The unit has special 20-in track rollers—with separate guide disk for

movement along track. When in position, they carry 70 percent of the weight of the machine and are locked into position when in service.

All traction for propelling machine is obtained through the extreme rear rubber-tired wheels on top of track ties. The rubber tires have floating action which permits the machine to go over switches, etc. The machine can be placed on track at a road crossing in 2 min and can be removed from the track at a road crossing in 1 min.

The pile hammer has a 2,800-lb ram, delivering an average striking energy of 16,800 ft-lb per blow. The usual lead is 55 ft. With the best average per hour on track, this machine drove five 45-ft piles per hr.

A 20-percent greater production was secured with this machine over the use of the standard pile driver, and a bridge hoist was available for handling material, etc. Also the complete cost of work trains was saved.

Other tools of value described in our report are torque-control-type wrench, power-driven pile augers and 12½ and 15-ton truck-mounted hoists.

You will see the pile-driving machine in the motion picture to be shown later.

President Woolford: Thank you Mr. Chapman. Your report will be received as information.

Assignment 6—Relative Economies to Be Derived from the Use of Tie Pads in Various Locations and Under Varying Circumstances.

Chairman Loggins: Assignment 6 is under the direction of Subcommittee Chairman R. H. Carpenter, engineer maintenance of way, Missouri Pacific Railroad. Mr. Carpenter has requested information from many railroads and will submit a report at the next meeting.

Assignment 7—The Specific and Ultimate Improvements in Various Types of Track Maintenance Equipment that Would Provide the Greatest Economies in Maintenance Practices, and How These Potential Economies Would Compare with Present Costs.

Chairman Loggins: The report on Assignment 7 will be given by Subcommittee Chairman P. A. Cosgrove, division engineer, Illinois Central Railroad.

P. A. Cosgrove: Mr. President, members of AREA, and guests:

The report on Assignment 7 lists the improvements recommended to track maintenance equipment. Our questionnaire was sent to 40 railroads, and replies were received from 25, from which the information shown in the report was compiled.

The reporting railroads indicated that this is an important subject to them as they are attempting to bring about all possible economies. We are certain that everyone is continuing in his efforts to develop ideas, such as those presented in this report, in order to bring about increased production of maintenance work at a minimum cost.

This is a final report, submitted as information.

President Woolford: Thank you Mr. Cosgrove. Your report will be so received.

Assignment 9—Relation Between the Nature of Traffic and the Interval Between Out-of-Face Resurfacing of Tracks of Relatively Similar Characteristics.

Chairman Loggins: The report on Assignment 9 will be given by Subcommittee Chairman R. W. Pember, assistant division engineer, Louisville & Nashville Railroad.

R. W. Pember: Gross tons of traffic moved is not a controlling factor in determining the interval between out-of-face resurfacing.

This lack of relationship between traffic and the out-of-face resurfacing cycle was developed from replies to a questionnaire sent to 56 railroads. A total of 26 railroads replied to the questionnaire. Six did not complete the questionnaire.

The railroads were asked to report gross tons of traffic handled and the out-of-face surfacing cycle in years for a selected typical territory (giving location) based on weights of rail varying from lighter than 100-lb section to heavier than 132-lb section. Forty-three combinations of rail weights, out-of-face resurfacing cycle and gross tons carried were reported by the 20 respondents.

The 20 railroads responding to the survey reported operations in 22 states, which include all regions of the United States except the far West, and Canada. This study showed that the out-of-face surfacing cycle does not vary to any appreciable extent among the geographical locations reported.

A summary of the replies received shows that of 43 combinations reported 31 were scheduled in either 4 or 5-year periods, with the remaining 12 ranging from 3 to 10 years.

From the total combinations reported 72 percent were in the 4- or 5-year out-of-face resurfacing cycle for all rail sections and for both heavy and light tonnage.

One respondent reported that "subgrade conditions, and age and condition of rail have more effect on the out-of-face resurfacing cycle than gross tons of traffic," while another reported that "general roadbed condition affected the out-of-face resurfacing cycle."

From the replies received it may be concluded that when out-of-face resurfacing is programmed on a cycle basis, such factors as tie renewals, rail weight and roadbed conditions are considered as the controlling factors in obtaining the optimum requirements for maintenance rather than the highly variable factor of traffic.

It is recommended that the subject be discontinued.

President Woolford: Thank you, Mr. Pember. Your report will be received as information.

Chairman Loggins: Mr. President, that concludes our subcommittee reports, but we now have a special feature, the Southern Railway film entitled, Mechanized Bridge and Building Gangs.

[The film was shown.]

Chairman Loggins: We are indebted to the Southern Railway for having made this film available to us through their chief engineer, George Echols, and through J. F. Beaver and R. L. Fox, who are members of our committee.

Mr. President, that completes our report.

President Woolford: Thank you, Mr. Loggins, for your effective direction of Committee 22's work during the past year and for the interesting and informative reports presented to this convention. It is of vital importance that Committee 22 continue to keep us informed on every possible means or procedure to effect economies in maintenance of way and structures operations and improve the quality of our work.

We are sorry Mr. Fox wasn't here today, but we want to express our appreciation to him for this film. I am sorry the operator spent so much time showing it. He ran it at about half the speed it should normally be run.

I think that even though Mr. Fox isn't here, Mr. Echols is probably here, and Mr. Beaver, and we want to congratulate them and their railroad for the way that they are ahead of many of us in the matter of mechanization. I am sure that many of us could take a page out of their book to our advantage. Thank you again, Mr. Loggins. Your committee is excused with the thanks of the Association. [Applause]

Gentlemen, the report of Committee 22 winds up the committee reports for today. Tomorrow, we will continue with an equally interesting and informative group of reports and addresses, beginning at 8:30 am in the Grand Ballroom.

Our registration up to 3:00 o'clock this afternoon was: railway men, 1064; non-railroad men, 651, or a total of 1715. The ladies' registration was 275, and at the ladies' luncheon today the attendance was 243.

Tomorrow's session, gentlemen, will also include our Closing Business Session, with the installation of officers for the enusing year. I hope you will find it possible to remain for that ceremony.

Now, as I announced earlier, we have another feature we would like to put on this afternoon. I see Mr. Magee is here and I am going to ask him about how long it will take for him to give us a rundown on the prestressed tie installation on the Seaboard Air Line and the Atlantic Coast Line. Mr. Magee, how long do you think it will take? Well, gentlemen, it will take him only 20 min. I am afraid if we put it over until tomorrow, we are not going to get this in at all.

Gentlemen, Mr. Magee, director of engineering research, AAR, will give us as quick a rundown as he can on the prestressed ties. It will probably make some of you 30 min late to your affairs tonight but personally I think you will find it worthwhile. Mr. Magee.

Prestressed Concrete Ties

By G. M. Magee
Director of Engineering Research, AAR

G. M. Magee: Thank you, President Woolford. I would like to ask the operator to show four of the slides first and then the movie.

Just as a little introduction, our research engineer structures, E. J. Ruble, had occasion to be in Europe three years ago to inspect some prestressed concrete bridges. He was impressed with the prestressed concrete ties he saw there. When he came back, we discussed the possibility of making such ties. We made some tentative designs, but it looked like they would cost about $14 each, and that rather dampened our enthusiasm. However, we thought we ought to go ahead and design the best tie we could, so we proceeded accordingly. For the past three years we have been working on this. We had ties of our three preliminary designs, A, B, and C, prepared and tested at the laboratory. Then, a year ago, representatives of the Florida Prestressed Concrete Company came in and said they were interested in building a machine for automated low-cost production of prestressed concrete ties. They said they would like to have us give them the design, and they would manufacture the ties. Also, they said they would like to have us arrange for two quarter-mile test sections to be placed on the Seaboard and the Atlantic Coast Line Railroads, and they agreed to furnish the ties for these two tests. So the whole thing was a cooperative project between our Association and the Florida Prestressed Concrete Company, which set up a separate company, now called American Concrete Crosstie Company.

In view of all the publicity and the fact that these installations just went in last week, it seemed that it would be timely to bring this to the convention at this time, although it had not been planned for. Mr. Woolford very kindly made arrangements to give me a chance to show these pictures now.

With all the publicity that I think most of you received on the so-called Ties of Tomorrow, may I say that this is a slogan invented by the American Concrete Crosstie Company, and I would like to take this opportunity to explain this to you.

The design of the tie is our design, and the patent rights are controlled by the Association of American Railroads, if there are any patent rights. Any company is at liberty to manufacture this design of tie. The objective of the American Concrete Crosstie Company, is to develop a mass-production automated machine that will build a good tie and do it cheaply.

This slide shows a test section of different types of concrete ties in Europe. You will notice there are several different kinds. Some of them are prestressed; some are combination steel and concrete.

This is the section or plan of the final tie that we decided on, which we call Type E. The special feature of it is that it is designed to be used on 30-in centers rather than 20-in centers. It is 12 in wide at the bottom, and 9 in wide at the top, at the end, for the rail support. The bottom part is concave so it will better hold the ballast. The midportion for about 3 ft is wedge-shaped on the bottom, with the expectation that this will keep the track from becoming center-bound.

With this particular tie, we used two different types of fastening. In half of the ties that went in, the two bolts that secure the rail tie plate assembly were screwed into a channel section that was inserted in the bottom part of the tie with two nuts welded to it. In the other half a kind of a wedge-shaped recess was cast in the tie, and a special wedge-shaped nut was rammed up and sealed into that, and then the fastening bolts were screwed into these wedge-shaped nuts.

This shows the type of fastening that was worked out to be used. There is a tie pad, an insulating pad, to also absorb some impact, between the tie and the tie plate. Then there is a heavy, heat-treated steel clip. One end rests in a recess in the tie to keep it from turning. The other end rests on top of the rail base. There is an insulating thimble that goes into the clip and into the tie plate and also on top of the clip. Then a solid washer and a double-coil washer and the bolt. In this way the tie plate is insulated from the tie by the pad, and the bolt is insulated from the tie by the thimble, so we have full insulation for track circuits.

Now, can we see the movie, please. This movie was made through the courtesy of the Portland Cement Association. It shows some of the laboratory test work that we carried on. This shows the tie being turned over in the laboratory. You can see the wedge shape design on the bottom.

Question: What do they weigh?

Mr. Magee: They weigh about 560 lb, I believe, or 580—a little under 600 lb—just a nice size to pick up and carry around.

This shows the assembly of the fastening, the tie pad and plate first being placed in position.

A section of rail is then placed in the tie plate seat, the clips are placed on each side of the rail, then the two thimbles, the double-coil springs, and the bolts.

Incidentally, the greater weight of the concrete tie we feel has some added advantages with continuous welded rail, because this weight should offer some increased resistance to hold the track in line and keep it from raising up or buckling in hot weather. I am not saying it is necessary, of course, to be used with continuous welded rail, because we know from experience we can use continuous welded rail with conventional wood ties quite satisfactorily.

Our design calls for each of these clip bolts to be tightened to 10,000 lb tension. which gives a good grip on the rail, not only to give the track stability but also to prevent creeping of the rail.

Rail anchors are not used. The friction provides the necessary rail anchorage. Rail anchors placed on the rail and bearing against the side of the tie would, of course, defeat the purpose of the insulation that has been provided.

Here are the tests that are being made to determine the flexural strength of the tie, in one of the Amsler hydraulic machines at the laboratory. The tie to be tested with the plates and rails and the complete assembly is placed in this machine. It is supported for about 1 ft at each end on Fabreeka pads and then it is loaded with the hydraulic jack.

We carried out two types of tests. I believe in this first one that is being shown here, it was a repeated-load or fatigue test. There is an interesting thing to me about prestressed concrete. You will notice the amount of deflection that you can get without any cracking. I imagine most of you may have seen this tie at the exhibit last fall. As you know, with prestressed concrete, the concrete is put into about 3000 psi compression over the entire cross section by the force put into the prestressing strands. Therefore, when you apply a load that would otherwise produce 3000 psi tension in the bottom and 3000 psi compression in the top, all you do is relieve the compression in the bottom and add on to the compression in the top so as to get the 6000 lb that was in the designed strength of the concrete; so that actually the tie as it is being flexed in track does not go into tension. This is one of the things we count upon in our hopes that we can get a long life from the tie.

Here, a static test to failure is being made in this same Amsler equipment. The load is gradually increased until failure occurs.

Question: You wouldn't get as much flexure upon soil as you do on your foundation there, would you?

Mr. Magee: These ties are designed to withstand 150,000 in-lb of moment. In the laboratory test we put them on fixed supports so we would know just what moment we were applying with the loading, and they were tested at that moment. We think that that probably is a somewhat higher bending moment than they would ever get in track. Incidentally, we will have a chance to check on that, because I think in six of the ties that we put in on the Seaboard, we put SR–4 gages on the bottom before they were installed, and we plan on measuring the flexural stresses in service.

These two machines were designed to test the fastening. They apply on each cycle a vertical load, and on the upstroke, a 20,000-lb vertical load is combined with an 8000-lb horizontal load in what would be outward of the track. On the down stroke it applies the 20,000-lb vertical load combined with a 4000-lb horizontal load in what would be inward of the track.

This first test as shown here is being made with conventional cut spikes, tie plates and a tie pad, on a treated red oak tie. In the twin machine this is a test on a section of prestressed concrete tie, and I think you can see the considerable amount of difference in the amount of movement of the rail and plate—how much more securely it is held here. We thought that if a tie pad would withstand 5,000,000 cycles of loading in this machine, we ought to expect it to last pretty well out in the track. The two types of pads that we are using, treated wood marine plywood and polyethylene plastic, have performed satisfactorily in this accelerated wear test.

Here is the test where we have compared 5-ft lengths of track with two concrete ties on 30-in centers with three wood ties on 20-in centers. We applied a simulated diesel axle loading of 65,000 lb for 5,000,000 cycles of loading, which would be equiv-

alent to about 350,000,000 tons of traffic carried. In a good grade of crushed granite ballast—I know this is very good because we got it from Mr. Meyers of the North Western and he speaks very highly of it—there was very little difference in the amount that the track was pressed down into the ballast with 5,000,000 cycles of loading. It was only about ⅛ in. in each case. There was no indication of the concrete ties becoming center bound. We repeated this test in a type of chat ballast, which I believe is the worst in the country to become center bound. The concrete ties did not become center bound and the wood ties did, so we are hopeful from this indication that the type E tie will do what we want it to in the track and not bring about that condition.

I have some pictures taken just last week of the installation being made on the Seaboard. This shows the tie pusher taking out the old wood ties. The quarter-mile of continuous welded rail had been laid first on the existing wood ties. The 30-in centers were marked off on the rail base and then every other one, or on 60-in centers, the wood ties were removed, the concrete ties placed, and after they were placed and fastened, the remaining wood ties were removed and the remaining concrete ties put in. Special equipment had to be used for unloading the ties, but aside from that, all the rest of the work was done with conventional tie application equipment. This shows the men unloading the ties several feet away from the track. They are shown here pulling them up closer, so they could be reached with the Nordberg Gandy tie puller, which is shown in the next slide, and which was used to pull the ties into the track.

The next slide shows tamping the ties. The ties were nipped up. The initial tamping was done with this multiple electric tamper for every other tie. You can't see it too well there, but in between those ties there are two wood ties that are covered up with ballast.

This shows the group that was down last Wednesday at the dedication ceremony on this section of track and you are looking at the finished section of track. They had a Golden Bolt ceremony. The American Concrete Crosstie Company had two tieplates with the clips, bolts, and spring washers gold-plated, which were installed on this one tie, and it was called the installation of the Golden Bolt. We used the regular AREA design plate for 115-lb rail, but it was sheared to a 5-in length rather than 7¾, 8, or 8½ in as usually used.

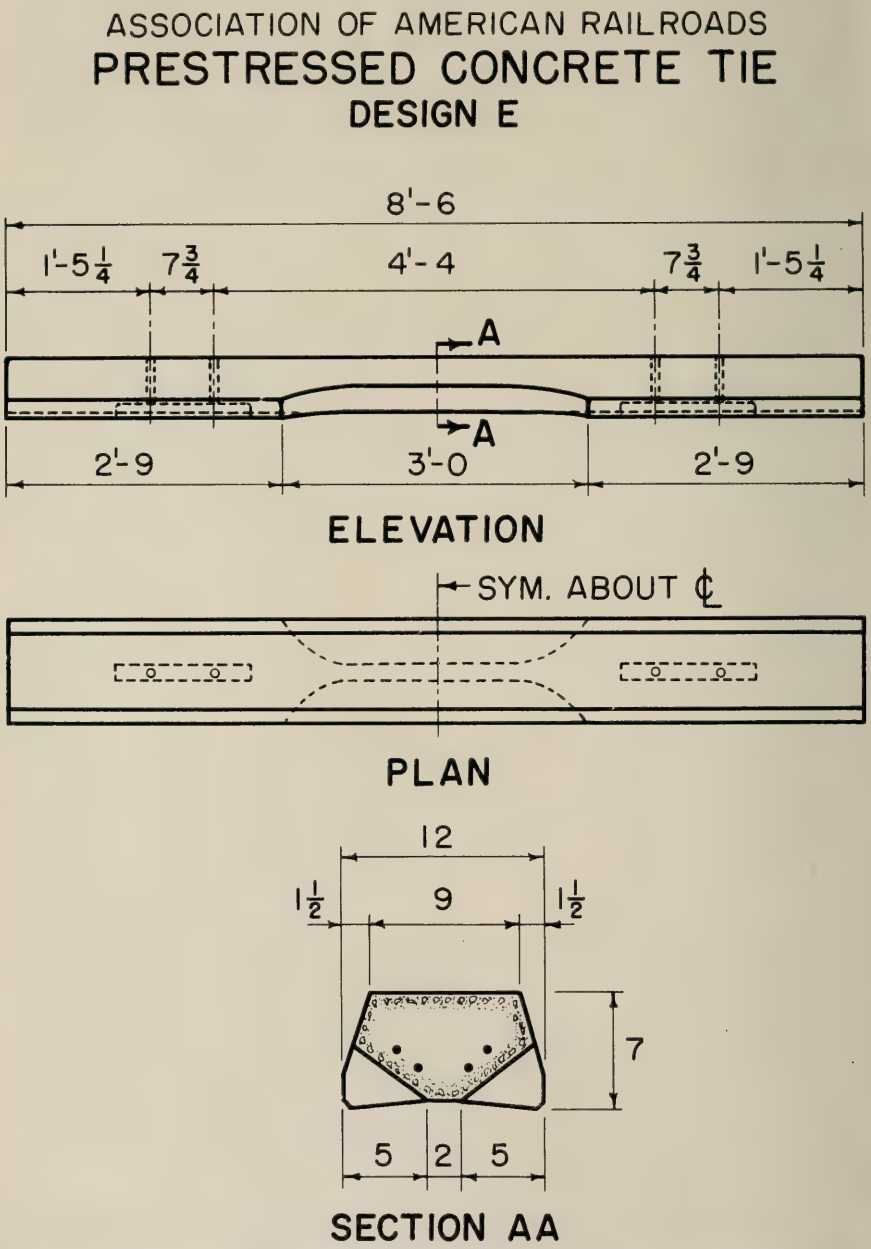
Here is a close-up view from the side of the assembled plate and clips. Incidentally, this is the gold-plated one. They are not all like that.

Here we have a train passing over the track. It has been in operation and it looks very good as the trains pass over it.

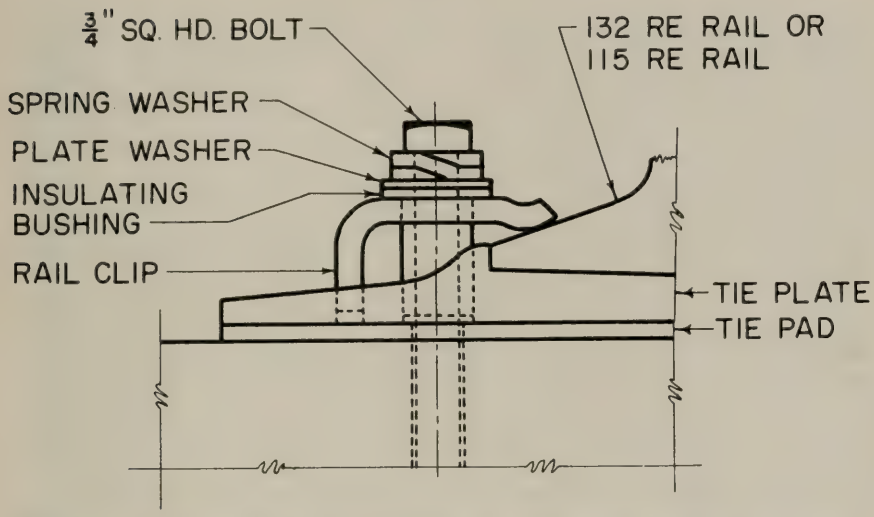
The next view shows the surface of the track and they really did a beautiful job. I am not going to take time to describe all the equipment used, but the final tamping was with the regular Matisa tamper, adjusting the clearance to a minimum of 14 in. They used the Nordberg lining and surfacing equipment with the wires, and it is really a beautiful piece of track. This shows at each end where they put in a few 39-ft rails with the concrete ties, and I have included this slide just to show the special clip we had to use where the rail joints came. The regular clips wouldn't fit there.

We have just a few more slides. Mr. Woolford has very kindly given us some slides of some installations that he has made. Frank, I don't know very much about these. Would you comment on them.

President Woolford: These are prestressed concrete ties that we poured out in California. They were poured to a design similar to that Jerry just described. We used a different type of fastening than he used, 3 different kinds, and we placed the ties on 26, 28 and 30-in centers. We think the 30-in center is too great, so in the experiment



Slide 1—Final design of "Type E" prestressed concrete tie used in the Seaboard and ACL installations.



Slide 2—Design of rail fastening assembly used. Approximately, 10,000 lb tension was applied to the clip bolt.

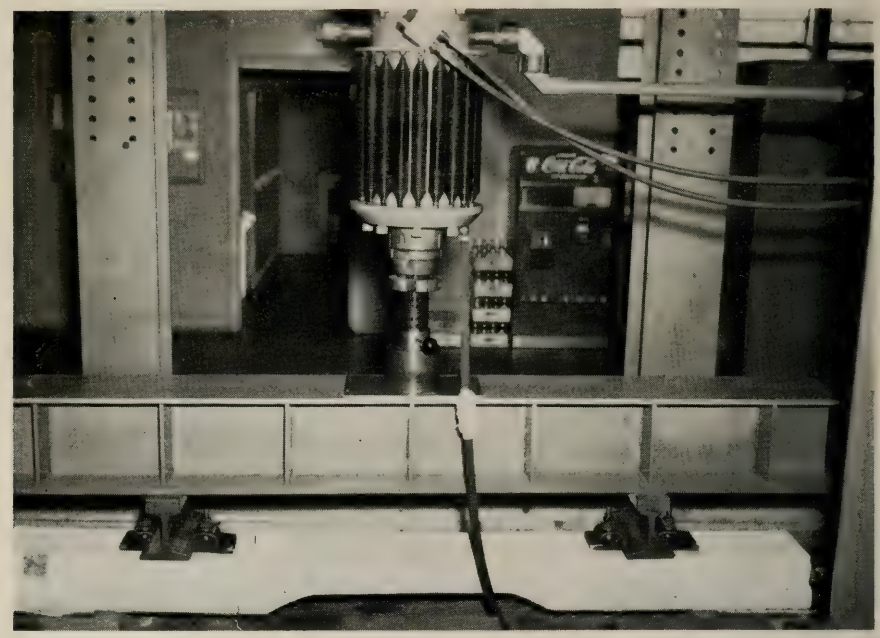
we put them on different centers. There are 50 ties placed there in three different locations. It happens to be a location where we are putting in a new slip, and while the track was out of service, we installed these just like they install concrete ties in Germany. We understand from German experience that you can't put in ties and tamp them up after they are in with any success. So we had the bed prepared, the ballast compacted, the ties placed on it, the rails placed on the ties and the cribs filled with ballast.

This shows the process of getting ready to put them in. They are cleaning out the ballast and getting ready to bring the ballast in and compact it. This is a slide of the slip where we are working. It introduces the transfer slip. We took right off of the switch and went right to the transfer apron. Those ties are 9 in on top and I think 12 in on the bottom, and they are built in kind of what we call a butterfly shape, which is supposed to do away with center bound track conditions.

We used a crane to install these ties. We thought they were too heavy for manpower to handle. They weigh about 540 lb each. We used two different kinds of ties. Some ties we poured with lightweight concrete and prestressed them, and the others we poured of standard concrete to about 6,000-lb strength.

This shows the ties in the track and we are placing the rail on them. I don't know what spacing this is. It looks like the 26-in spacing. We have the ties, as I said, on three spacings to see how they work out.

This is another view of putting the rail on the ties using a crane. This is a close-up view of the plates. These ties have a cant in them, so we had to use flat plates. These

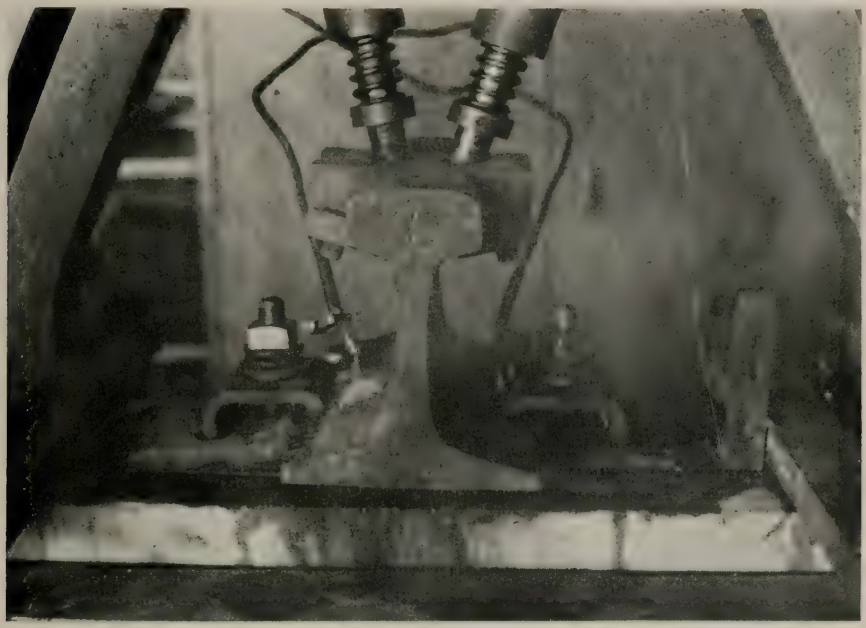


Slide 3—Tie tested to failure with the Amsler hydraulic repeated-load testing equipment at the Research Center.

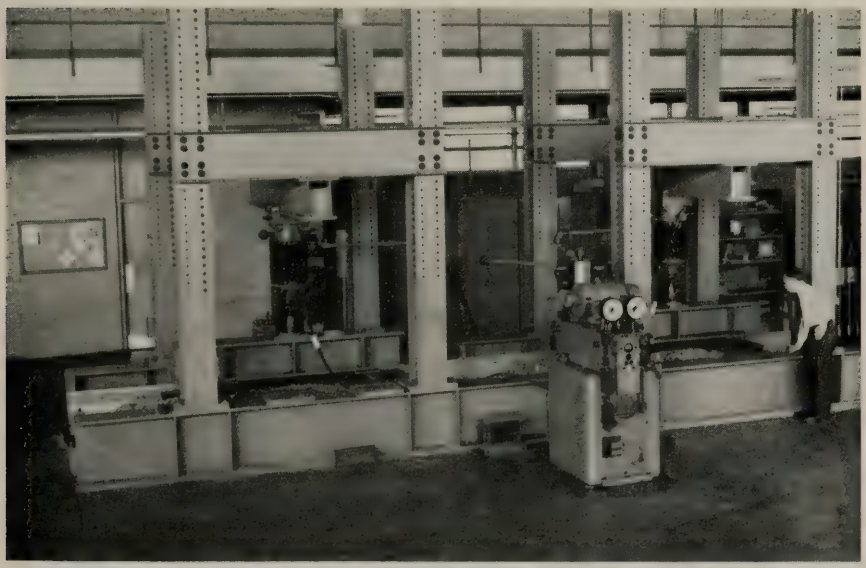
were delivered to us in a hurry and I wanted to get them in before I left, so it wasn't too important what kind of plates we got. They are not shoulder plates, just flat plates, and we punched the side holes and made the installation. It took us about a day and one-half to put in these 50 ties.

Of the ties we put in, one-third had two bolts, one-third had hardwood wedges embedded in them when they were cast, into which we put lag screws, and one-third had keepers that we poured in the ties with threads in them. We used clips to hold down the rail and under the plates we used marine treated plywood. This track is not in signaled territory, so we didn't have to worry about the insulation of the track.

Mr. Magee: I just want to add one thing. With the air entrainment and the prestressing, with continuous welded rail, where we don't have batter at the joints and where the vertical wear of the rail is rather unimportant, and with grinding facilities, I personally don't think it is too far fetched for us to begin to think about 50-year track. Thank you very much. [Applause]



Slide 4—Rail fastening assembly being tested in the repeated-load testing machine at the Research Center.



Slide 5—Repeated-load testing to determine stability in the ballast of two 5-ft panels of track with two concrete ties on 30-in center versus three wood ties on 20-in centers.

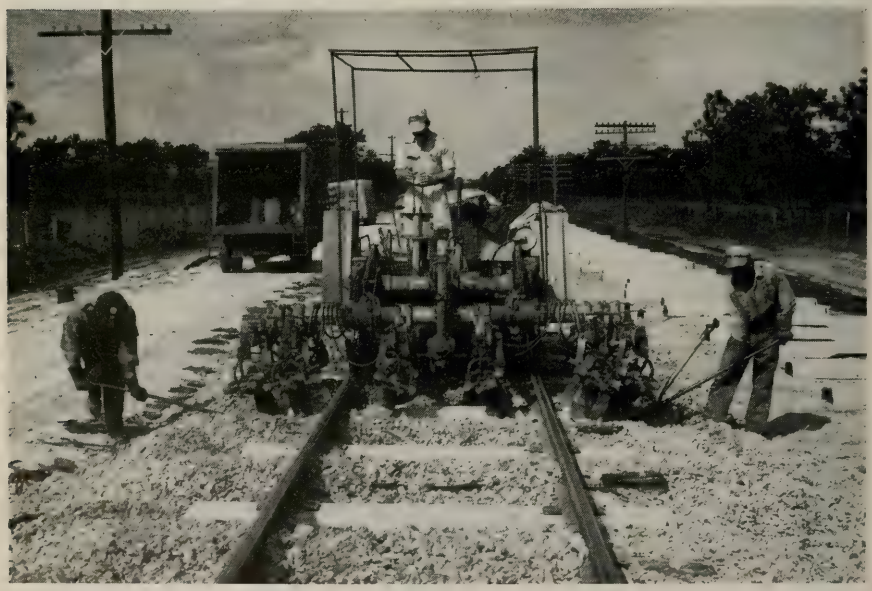
Slide 6—Pushing the wood ties out of place with a Fairmont Tie Remover.

Slide 7—Unloading the concrete ties alongside of the track.

Slide 8—Pulling the ties in close to the track so they can be reached with the tie puller.

Slide 9—Cleaning out the ballast with a Fairmont Tie Bed Scarifier to facilitate insertion of the concrete tie.

Slide 10—Inserting the concrete ties with a Nordberg Gandy Tie Puller.



Slide 11—Making the initial tamping with a Jackson Multiple Tamper.

Slide 12—Tightening the clip bolts with a Raco Power Wrench and adaptor.

Slide 13—Part of the group attending the dedication ceremonies on the Seaboard near Tampa on March 9. The fastenings for one tie were gold plated for the "Golden Bolt" ceremony.

Slide 14—A Nordberg Power Jack and Trak-Surfacer were used to give the final raise to the rail.

Slide 15—A RMC Line Master and Line Indicator were used for the final lining operation.

Slide 16—The final tamping was made with a Matisa Tamper.

Slide 17—The completed track, one-fourth mile in length, laid with new 115 RE continuous welded rail.

Morning Session, March 16, 1960

[The meeting convened at 8:30 o'clock in the Grand Ballroom, President Woolford presiding.]

President Woolford: The meeting will please come to order. We now begin the final technical session of our convention, with four of our committees yet to be heard from, which means that we must start promptly and keep moving if we are to begin our closing business session on schedule and adjourn about noon.

Discussion on Roadway and Ballast

[For report, see pp. 649–828.]

[President Woolford presiding.]

President Woolford: The first committee to report this morning is Committee 1—Roadway and Ballast, the chairman of which is G. B. Harris, assistant engineer, Chesapeake & Ohio Railway, at Richmond. Mr. Harris, if you will bring your committee to the platform, I shall be glad to turn the meeting over to you.

As the committee comes to the platform, may I remind you that you have the privilege of the floor, and that we will welcome comments and discussion to the extent that time will permit. The microphones are on the floor and we have people attending them. This is your convention; we think you should say so if you disagree with anything that is said up here on the platform.

Chairman G. B. Harris: Mr. President, members of the Association, ladies and guests:

The report of Committee 1 will be found in Bulletin 556 on pages 649 to 828, incl.

I had the pleasure last year, on behalf of the committee, to award the degree of Member Emeritus to one of our most distinguished members—A. P. Crosley, past chairman of Committee 1 and retired engineer maintenance of way, Reading Company. I might add that Mr. Crosley has the unusual distinction of being the only member of the committee to have served as chairman twice.

At this time I would like to take the opportunity to express not only my personal sorrow but that of the whole committee at the passing of one of our most beloved and valued members, Charles Weiss, retired research analyst, Pennsylvania Railroad, who died at St. Vincent's Hospital, Portland, Ore., on July 26, 1959. He had been a member of the Association since 1947 and a member of Committee 9 from 1948 until 1950, when he transferred to Committee 1. A memoir in honor of Mr. Weiss is included as part of our report.

I also regret to announce the death of R. A. Gravelle, engineer maintenance of way, Grand Trunk Western Railroad. Mr. Gravelle became a member of the Association in 1927. He was a member of Committee 5—Track, 1941–1949; Committee 1—Roadway and Ballast, 1949–1958; and Committee 22—Economics of Railway Labor, from 1958 until the time of his death. Committee 1 has included a short memoir, in his honor, as part of its report. However, a more complete one appears as part of the current report of Committee 22.

This year your committee reports on 8 of its 11 assignments. We solicit your comments, suggestions or criticisms in connection with any of our reports. We may not be able to answer all the questions you may have at this time, but in such a case we shall certainly attempt to find the answer for you.

We have only one Manual recommendation this year and it will be presented by the subcommittee involved instead of under Assignment 1—Revision of Manual.

Mr. President, the various subcommittees of Committee 1 have done a tremendous job this past year, as is evident by the size of our report. In order to recognize the members of these subcommittees, with your permission, I would like to request the members of each subcommittee to stand when the chairman is introduced and remain standing until he reaches the podium.

Assignment 2—Physical Properties of Earth Materials.

Chairman Harris: I shall present the report on Assignment 2 in behalf of the subcommittee chairman, W. P. Eshbaugh, chief engineer, Genesee & Wyoming. [Mr. Harris then read, in part, the subcommittee report as presented in Bulletin 556.]

Assignment 3—Natural Waterways: Prevention of Erosion.

Chairman Harris: G. W. Becker, special engineer—drainage, Chicago, Rock Island & Pacific Railroad, chairman of Subcommittee 3, will present our next report.

G. W. Becker: Mr. President, members, and guests:

Activity in the construction of reservoirs in this country for use in flood control, irrigation, navigation, power, or for a combination thereof, has been increasing in recent years.

As an example, in the four states of Kansas, Oklahoma, Arkansas and Missouri there are now approximately 27 completed reservoirs; 13 additional reservoirs are under construction; and 36 new ones have been authorized but not started.

Admittedly, benefits to be realized from these projects are great. Less well known, however, and of particular interest to engineering maintenance personnel, is the effect of the operation of a reservior on downstream river banks and bank protection installations. Accelerated erosion of streambeds and banks through reservoir operation may often become a major consideration in bank protection studies.

Your committee's report in Bulletin 556, beginning on page 658, discusses and illustrates some of the effects resulting from desiltation of streams, and highlights possible damage to river bank protection already in place because of the dam's influence on river characteristics in the reach downstream from the structure.

This report is submitted as information.

President Woolford: Thank you, Mr. Becker. Your report will be so received.

Assignment 4—Culverts.

Chairman Harris: Our only recommendation for revision of the Manual comes under Assignment 4. Subcommittee Chairman G. D. Mayor, division engineer, Chesapeake & Ohio Railway, will present the report.

G. D. Mayor: Mr. President, members and guests:

Your committee has found it desirable to revise the Specifications for Corrugated Metal Pipe for Subdrainage, in order to bring them in line with present manufacturing standards.

The major revisions are in the table and are intended to make the data therein agree with similar data in other standard perforated corrugated metal pipe specifications. The changes will provide adequate opening for admission of ground water and provide a wider unperforated segment to carry the normal flow.

The revised specifications are printed on pages 663, 664 and 665 in Vol. 61, Bulletin 556, February, 1960.

Mr. President, I move that these revised specifications be adopted and published in the Manual, replacing the present specifications found on pages 1–4–11 and 1–4–12.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 5—Pipelines for Conveying Flammable and Non-Flammable Substances.

Chairman Harris: K. W. Schoeneberg, chief engineer, Akron, Canton & Youngstown, and chairman of Subcommittee 5, will give us a progress report on the activities of his subcommittee.

K. W. Schoeneberg: President Woolford, Chairman Harris, members and guests:

The report on Assignment 5 will be found on pages 665 through 670 of Bulletin 556.

This report represents a composite of studies, collaborations and recent developments dealing with pipeline crossings and longitudinal or parallel occupancy of railway right-of-ways, with the view of combining them into a single set of recommended practices for our future guidance. The specifications or recommended practices as presented in this report are not complete, or final, and are certainly subject to change prior to their submission as Manual material. Even while this report was being put into print certain aspects, or portions, were being revised.

Of great help in the committee's work of revising our specifications is the work being conducted by the AREA representatives on the American Society of Civil Engineers' Committee on Pipeline Crossings of Railroads and Highways. As reported last year, this ASCE committee has held several meetings, and the various task groups within this organization have been diligently trying to formulate specifications of design, construction and maintenance of pipeline crossings under railroads and highways. At our February 1960 meeting many areas of disagreement were resolved, and a more mutual meeting of the minds prevailed. To give you a better insight as to what is being accomplished and what is hoped to be accomplished through this ASCE organization, I quote from a report submitted by its Liaison Task Group for distribution to the sponsoring organizations, of which the AREA is one.

ASCE Committee on Pipeline Crossings of Railroads and Highways, Meeting of February 15, 16, and 17, 1960—Liaison Task Group Report

The primary purpose of this meeting was to evolve an overall specification which could be submitted to the full committee for its consideration. This required that the dissents to the proposed design criteria, particularly on cased crossings, be resolved. With a few minor exceptions, this resolution was accomplished.

The method of calculating total stresses for uncased crossings contained in previous drafts of the specifications was discussed at considerable length by the Design Criteria Task Group. It was agreed that more factual information and research data are needed for developing an accurate method of calculating total stresses in pipe due to internal hoop stress and secondary stresses. As a result, a research program is being augmented to obtain this information.

Following the full committee action on the sections of the proposed specifications the completed document will be submitted to the sponsoring groups for consideration as "interim" specifications. Following the review by the sponsoring organizations, the specifications will be available for use by the various industries as interim specifications until such time as the data developed from the research program, i.e., actual casing performance, moduli of passive resistance, treatment of total uncased pipe stresses, etc., can be evaluated and used in the specification where applicable.

The Research Council discussed the activation of the research program at great length. There now will be three phases to this program:

a. *Actual field casing performance*—The first of these test casing installations will be near Thorsby, Ala. The Transcontinental Gas Pipe Line Company will su-

pervise the overall installation and make certain of the required data measurements. The AGA–PAR Pipe Research Committee for Project NG–22, "Secondary Stresses", will make the necessary strain gage installation and initial tests. There will be three casings (without carrier pipe) installed at this site under the L & N Railroad; specifically, the casing sizes are 30 in, 36 in, and 42 in. Later this year, test casings will be installed by the El Paso Natural Gas Company and the Northern Natural Gas Company, at their own expense. During the course of the casing performance tests, it may be possible to internally pressurize one of the casings in order to obtain data on uncased carrier pipe performance.

b. *Laboratory*—One phase of this portion of the research program will be conducted by the Utah State University. This will consist of a laboratory examination of the modulus of passive soil resistance. It is anticipated that this particular program will be activated within the next few weeks.

c. *Full-scale tests—laboratory*—At the February 15 meeting, the second phase of the laboratory portion of the research program was initiated. This will consist of the examination of pipe performance under various types of soil and surface loadings and will be conducted at the AAR Research Center, Chicago. The AAR laboratories have the facilities to produce any types of soil and static and dynamic surface loadings desired in order to simulate field conditions under controlled laboratory conditions.

Until such time as the ASCE Committee on Pipeline Crossings of Railroads and Highways presents their final draft of a code for pipeline crossings that will be acceptable by all concerned, and until such time as the AREA accepts this code in lieu of its own code, or specifications, we will continue to publish and use our own. To that end, and as stated previously, your committee is endeavoring to revise our present-day specifications to include new facts and findings.

This report on proposed specifications is submitted as information only.

President Woolford: Thank you, Mr. Schoeneberg. Your report will be so received.

Assignment 6—Roadway: Formation and Protection.

Chairman Harris: Our report on Assignment 6 will be presented by Subcommittee Chairman F. N. Beighley, roadway engineer, St. Louis–San Francisco Railway.

F. N. Beighley: Under Assignment 6 your committee submits two reports as information: (1) "Investigation of Landslides for Planning Remedial Measures", prepared by Ralph B. Peck and Don U. Deere of the University of Illinois, and (2) "Performance of Filter Material", prepared by John C. Guillou, also of the University of Illinois.

The work represented by these reports is part of the research sponsored by the committee and administered by the Research Department, AAR, under the direction of G. M. Magee, director of engineering research, and supervised by Rockwell Smith, research engineer roadway. The research has been performed at the University of Illinois under a cooperative agreement with that institution. Professors Peck and Guillou are in charge for the University.

President Woolford: Thank you, Mr. Beighley. Your report will be received as information.

Assignment 7—Tunnels.

Chairman Harris: J. B. Farris, assistant engineer, Southern Railway System, and chairman of Subcommittee 7, will present the report on Tunnels.

J. B. Farris: Mr. President and gentlemen:

Your committee submits as information a report on ventilation of the Great Northern's Cascade Tunnel under that part of its assignment dealing with Tunnel Ventilation; Changes Necessary for Operation of Diesel Power. The report appears on pages 694 to 714 of the February Bulletin.

The situation at Cascade Tunnel may be an unusual one. However, during the preparation of its report, your committee was impressed by the necessity of a thorough analysis of each tunnel where ventilation changes appear necessary.

This is presented as information.

President Woolford: Thank you, Mr. Farris. Your report will be so received.

Assignment 10—Ballast.

Chairman Harris: The report on Assignment 10 will be presented by Subcommittee Chairman R. H. Beeder, chief engineer system, Atchison, Topeka & Santa Fe Railway. At the conclusion of his report, Mr. Beeder will introduce our speaker for this morning.

R. H. Beeder: Mr. President, members of AREA, and guests:

Your committee reports this year on one of its two projects under Assignment 10—Ballast.

No report on Assignment 10 (a)—Ballast Tests, is being submitted this year as this project, using an Amsler Pulsator and hydraulic jacks at the AAR Research Center, failed to receive an appropriation to progress the work during the past year. The last progress report on this assignment was the sixth and was made last year.

The report on Assignment 10 (c)—Special Types of Ballast, is submitted as information and covers the treatment of more than 27 miles of ballast section with asphaltic materials on the Santa Fe Railway under the sponsorship of your committee, the AAR Research Department and the Asphalt Institute. In addition, one 12,780-ft open-deck bridge received a similar treatment on the Pittsburgh & West Virginia Railway.

The tests on the Santa Fe included six treated sections and equivalent untreated control sections of comparable tonnage, track and tie conditions. These test sections total a little less than 23 miles and all have welded rail, generally in approximately 1440-ft lengths. The asphalt spray coat and chip cover coat, costing about $900 per mile, were applied with a special asphalt distributor car and a hopper-type spreader car during the months of April and May 1959. The locations of the individual tests were selected to encompass a wide variety of climatic conditions, traffic densities, ballast types and other factors so as to give us a broader picture as the results become available in the future. Of course, sufficient time has not elapsed since treatment to permit an appraisal of possible benefits with respect to prevention of ballast fouling, increased tie life and reduced lining and surfacing, but comparative figures are being kept on the cost of maintenance of the treated sections vs. the control sections.

The work is jointly supported as cooperative research by the Asphalt Institute and the Research Department of the AAR, this latter group being directly represented in the field work by Rockwell Smith and George L. Hinueber. We have drafted Mr. Hinueber, whose Alma Mater is the University of Minnesota, for an illustrated talk giving more of the details on this asphalt ballast treatment. Mr. Hinueber has been with the Association of American Railroads for the past nine years, the first six years as assistant research engineer roadway and the past three years as engineering laboratory manager. Mr. Hinueber.

President Woolford: Gentlemen, while Mr. Hinueber is getting ready to give his talk, I think I should tell you that the hotel has advised me they have extended the check-out hour for all members staying at the hotel during the convention to 8:00 or 9:00 o'clock tonight. If you wish an extended check-out time, just notify the desk.

Highlights of Asphalt Treatment of Ballast

By George L. Hinueber
Engineering Laboratory Manager, Association of American Railroads

Asphalt materials possess unique cementing and waterproofing properties and have been used successfully for many years on highway construction. A railroad track and ballast section, in general, serves the same function as a highway pavement—that is to distribute traffic wheel loads over the subgrade soils.

In 1943 the first field test of any appreciable size was set up to explore the possibilities of using asphalt for treatment of railroad ballast. Engineering personnel of the Association of American Railroads, the Illinois Central Railroad and the Asphalt Institute planned and constructed a ½-mile experimental test section of asphalt-treated ballast using a type of application similar to the asphalt penetration macadam used in highway work. This test section was on the Illinois Central Railroad near Mantino, Ill.—some 46 miles south of Chicago. Makeshift equipment was improvised to apply hot asphalt cement to the track section over a total width of 13 ft. Asphalt cement, 85–100 penetration grade, heated to a temperature of 300 F was applied at the rate of approximately 2 gal per sq yd. A cover coat of ¾-in, No. 4 stone chips was hand spread over the area covered by the asphalt and then hand tamped. This was followed by a second application of asphalt at the rate of approximately 0.4 gal per sq yd, which was covered with ⅜-in, No. 10 stone screenings. The asphalt penetrated the ballast to a depth of 3–4 in. This ½-mile test section was observed for a period of 10 years, during which sufficient data were accumulated on treated as well as adjacent untreated track to permit evaluation of the treatment.

This test section of asphalt-treated ballast indicated that the asphalt penetrated ballast section is practical and beneficial. Some of the benefits derived from this treatment were: (1) increased stability of ballast section; (2) waterproofing of subgrade soil; (3) prevention of ballast fouling from blowing dust, cinders, debris, etc.; (4) reduction in pumping; and (5) increased tie life.

As an outgrowth of this investigation a 14-member joint committee was formed with representatives of the AAR, the Asphalt Institute and the AREA, the latter representation being composed of 7 members of Committee 1, for the purpose of planning and arranging additional experimental work of this nature.

Special on-track equipment was designed and constructed for the rapid and economical distribution of asphalt and cover cost materials. The construction of this equipment was financed jointly by the AAR and the Asphalt Institute.

The equipment consists of an asphalt distributor mounted on a flat car and a stone chip spreader car.

Slide 1—The asphalt distributor car is equipped with an asphalt pump which draws the hot asphalt through flexible suction lines from insulated tank cars on either end of the distributor car and, in turn, pumps it to three spray bars located under the car. The center spray bar, which sprays between the rails, is fixed while the outer spray bars, which spray outside the rails, are hinged and may be retracted when the car is in transit. The asphalt distributor car is also equipped with an oil heating and circulating system for maintaining heated asphalt supply lines.

Slide 1—View of the asphalt distributor car.

Slide 2—The chip spreader is a remodeled hopper car. The flow of chips is regulated by a system of rolls and gates. The center roll distributes the cover coat aggregate between the rails. The outer rolls, one on either side, feed the cover coat aggregate to belt conveyors on outriggers which, in turn, deposit it to the asphalt-treated areas outside the rails. The belt conveyors may be swung in and secured under the car when in transit.

Upon completion the equipment was turned over to the Santa Fe which had, in cooperation with the Joint Committee on Asphalt Treatment of Ballast, set up a test program comprised of 6 experimental test sections totaling 23 miles to be treated, together with equivalent adjacent untreated control sections. All of the test and control sections were inspected by representatives of the Santa Fe, the Asphalt Institute and the AAR prior to treatment. The weight of rail, type and size of ballast, and general track conditions, as well as the recommended rates of application of asphalt and cover coat aggregate were reported.

The quantity of asphalt applied on the various test sections ranged from ¾ gal per sq yd to 2 gal per sq yd, depending on the type and gradation of the ballast. The quantity of cover coat aggregate varied from 12.5 lb per sq yd to 30 lb per sq yd.

Slide 3 shows the asphalt application followed by the cover coat application.

Slide 4 shows the make up of the work train—the asphalt distributor car with asphalt tank cars on either end followed by the chip spreader, caboose, engine and rail cleaner car.

Slide 2—View of the chip spreader car.

Slide 3—Asphalt application (background) followed by application of cover coat (foreground).

Slide 4—Consist of the spreader train.

Slide 5—Typical view of track after application of aspalt and cover coat.

Slide No. 5 is a close-up view of the track and ballast after a typical application of asphalt and cover coat of aggregate.

The location of the first of these 6 test sections is between Barstow and Daggett, Calif. This is a 2-mile section with 136-lb continuous welded rail on volcanic cinder ballast. The application in mid-April 1959 marked the first use of the new equipment, and a few delays were experienced. The work was completed, however, in two days.

On this job the asphalt was applied at 350–400 F in two passes, the first of which was at the rate of approximately ¾ gal per sq yd. The volcanic cinder cover coat was spread immediately following the second asphalt application. The actual quantities applied were 1.38 gal of asphalt per sq yd and 21.3 lb cover coat aggregate per sq yd.

On Feb. 3, 1960, this test section was inspected. The section was a bit spotty, with some cracking of the asphalt-treated ballast at the ends of ties and some loose unconsolidated ballast in the cribs in places. The adherence of the asphalt to the ties was generally good, but there has been considerable whipoff of the cover coat of aggregate. It is believed that a greater quantity of asphalt should have been applied. However, with everything taken into consideration, the overall condition is fairly good.

Following the Daggett to Barstow application, one mile of double track in the vicinity of Victorville, Calif. and 1¼ miles of double track near Oro Grande, Calif. were treated. The track at both locations was on crushed gravel ballast. These sections were through cement-mill areas where flue dust caused fouling and cementing of the ballast and, although they were not included in the original test program because no adjacent equivalent control sections could be established, they should prove in a relatively short time the advantage that can be realized by treating the ballast section in selected trouble areas. Maintenance cost records will be kept for comparison with previous available records.

The rate of application for the Victorville job was 1¾ gal of 120–150 penetration asphalt per square yard applied in two passes, with the second pass followed by the application of 30 lb of crushed gravel screenings per square yard. The rates for the Oro Grande job were 2 gal per sq yd of 120–150 penetration asphalt on the eastbound main and 1¾ gal per sq yd on the westbound main, both applied in two passes followed by 25 lb per sq yd of crushed gravel screenings.

Both of these jobs were in excellent condition at the time of the Feb. 3rd inspection.

On April 24–25 a 5-mile test section between Peach Springs and Truxton, Ariz. was treated. This track has 136-lb continuous welded rail on volcanic cinder ballast. Asphalt cement, 85–100 penetration grade, was applied at 300–380 F at the rate of 1.18 gal per sq yd in a single pass and was followed immediately by 22 lb per sq yd of volcanic cinder screenings.

An inspection on February 4 of this year showed this test section to be in fair shape. There was considerable disturbance of ballast near tie ends, some disturbance in the cribs and a few pumping ties. There was loose ballast in some of the cribs, and the adherence of the cover coat to the ties was spotty. Indications are that more asphalt probably should have been used on this job.

On April 27–28, 1959, a 4-mile test section between Suwannee and Marmon, N. M. was treated. This track has 136-lb continuous welded rail and is on volcanic cinder ballast. Asphalt cement with a penetration of 120–150 was applied at a temperature of 350–380 F and at a rate of 1 gal per sq yd followed by 12.5 lb per sq yd of volcanic cinder screenings.

An inspection of this test section was made on Feb. 5, 1960, and it was found to be in poor condition. There was considerable disturbance of the asphalt ballast, and numerous pumping ties were in evidence. It was quite apparent that too small a quantity of asphalt was used on this job.

Next, a 4-mile test section between Topeka and Lecompton, Kans. was treated. This section has 3¼ miles of coarse chat ballast and ¾ mile of fine chat ballast. Asphalt cement, 120–150 penetration grade, was applied at a temperature of 320–340 F and at the rate of 1.29 gal per sq yd on the coarse chat ballast and ¾ gal per sq yd on the

Slide 6—Williamsfield to Dahinda test section before treatment.

Slide 7—Williamsfield to Dahinda section immediately after application.

fine chat. This was followed immediately by the application of 33.4 lb per sq yd of minus ½-in slag screenings.

An inspection was made of this test section on February 11 of this year, and the overall condition was excellent. The asphalt and chip coverage and adherence was very good on both the ballast and ties.

This job was followed by treatment of 4 miles of single track ballasted with blast-furnace slag between Bucklin and Marceline, Mo. Asphalt cement, 85–100 penetration grade, at a temperature of 315–350 F was applied at the rate of 1.34 gal per sq yd.

Slide 8—Bridge deck on P&WV immediately after treatment.

This was followed by the application of minus ½-in gravel cover coat aggregate at the rate of 33.4 lb per sq yd.

This test installation was observed in the late fall of 1959 and appeared to be in excellent condition.

On May 21, 1959, a 3½ mile test section between Williamsfield and Dahinda, Ill. was treated. At this location 1.25 gal per sq yd of 85–100 penetration asphalt cement was applied at temperatures of 300–325 F and was followed by 29.8 lb per sq yd of fine gravel cover coat aggregate. This test section was observed in the late fall of 1959 and found to be in excellent shape. Slides 6 and 7 show this test section before and after treatment.

On November 12–13, 1959, 12,780 lin ft of open-deck bridges on the Pittsburgh & West Virginia Railway were treated. Hot 60/70 penetration asphalt cement was sprayed at the rate of 1 gal per sq yd, followed by the application of minus ½-in slag screenings. Adjacent untreated sections were left where possible as control. Prior to the treatment a condition survey and inspection of the ties was made by representatives of the railroad and the AAR. This treatment was applied as a tie preservation measure. Slide 8 is a view of a treated bridge deck immediately after treatment.

These early applications were not made without difficulty. As the work progressed a number of necessary minor repairs and alterations were made on the equipment, which is now considered capable of applying the materials efficiently while giving good coverage. With these improvements the equipment has a potential of treating up to 5 miles of track per day. The quantities of asphalt and cover coat aggregate can be regu-

lated accurately. During the 1959 tests only asphalt cements of low to medium penetration were used. Other types of asphalt materials, such as cut-backs and emulsions, should prove satisfactory for ballast treatment and will be used as the investigation proceeds. All treatments so far on the Santa Fe have been for a 14-ft width and only on welded rail sections.

So far the costs have run from about $900 per mile for ballast treatment to $2000 per mile for open-deck bridges—this includes labor, materials, work train, etc. Improvements in equipment and know how will undoubtedly increase production and should lower these costs appreciably.

In connection with the testing program it is intended to collect data for evaluating this treatment under all possible conditions of climate and traffic and for all types of ballast. The equipment is available to the railroads free of charge, together with the services of engineers from the AAR and the Asphalt Institute.

It is our hope that this study will eventually show the way to substantial savings in maintenance of way costs. [Applause]

Chairman Harris: Mr. Hinueber, on behalf of the Association, and especially Committee 1, I wish to thank you for a most interesting and instructive talk. I might mention that we had a movie showing the application of this asphalt ballast coverage, but due to the time limitation, we decided to eliminate it at this time.

Assignment 11—Chemical Control of Vegetation, Collaborating with Signal Section and Communications Section, AAR.

Chairman Harris: Subcommittee Chairman C. E. Webb, engineer of tests, Southern Railway System, will present the report on Assignment 11.

C. E. Webb: The report appearing in Bulletin 556 consists of two parts. Part 1 is the final report on the planned and sponsored research at North Carolina State College. Part 2 is the report of the AAR research staff on field observations and tests conducted during 1959. Each year, additional chemicals and chemical combinations become available for vegetation-control purposes. At present there are more than 80 such materials, and very extensive efforts have been directed toward finding chemicals which would provide effective results at a more economical cost.

Tables 1 through 9 give the identification of the chemical formulation, the rate applied and results obtained in all regions. Table 10 lists the trade name, its composition, recommended rate per acre and approximate cost per acre. It is believed that use of these tables will provide excellent information on anticipated results at a given cost for practically any chemical formulation that is on the market.

Soil-sterilant-type materials were used primarily in yard areas, around bridges and trestles, buildings, road crossings and as spot treatment. These materials provided good results for one season in all regions when applied at the recommended rate. In low rainfall areas it is possible to obtain two years control.

Oils continue to be used primarily in the midwest, south and southeast. A single application provides fairly good control in the midwest. Two and three treatments are generally necessary in the south and southeast to maintain adequate control.

The low volatile ester and amine formulation of 2,4–D and 2,4,5–T continue to be used extensively for controlling brush in all regions, with ammate being substituted for these materials in areas adjacent to crops or in states where the use of these compounds are restricted.

An extensive test program was initiated on four railroads this year in an effort to determine better methods for controlling brush using granular or pelletized materials.

Various methods of application were employed. These were air gun, cyclone seeder, hand broadcast, stem application and aerial. Excellent results were obtained with stem application. The air-gun method also appears to be quite promising in applying dry materials.

The use of dry materials is primarily in the experimental stage. It is expected that these will have a definite place in a brush-control program, but method of application is one of the problems encountered in the use of these materials.

It seems unlikely that any specific compound will be found that will be successful on all types of vegetation under varying growing conditions. Observations indicate that a definite program for weed control is equally as important as the chemical formulation selected and that a long-term system-wide program continues to be more economical than those on a year to year basis.

This report is given as information only.

President Woolford: Thank you, Mr. Webb. It will be so received.

Chairman Harris: As I mentioned earlier, we have a rather large report in the Bulletin this year, and I want at this time to particularly thank the members of the AAR research staff, Rockwell Smith, George Hinueber and Cleston Parris, for the valuable assistance they have given us in preparing these reports and the work we have done this year.

We did not submit a report this year on two of our assignments—Fences and Signs. Under Fences, we have no specific sub-assignment, but the subcommittee is in the process of reviewing the present Manual material prior to submission in 1961 for reapproval or revision. We have two assignments under Signs—Reflectorized and Luminous Roadway Signs and Develop a Standard Close Clearance Warning Sign. A survey of commercially available atomic light sources has revealed that none was suitable for signs. Due to curtailment of research funds, the committee did not request continuation of this study by the Armour Research Foundation, but inasmuch as new products are coming out almost daily, it was felt we should look into the subject further before recommending that it be discontinued. Under our assignment to develop a Standard Close Clearance Warning Sign, the subcommittee has prepared several tentative plans which have been circulated, but to date, conclusions have not been reached as to the best design.

During the past year we had the misfortune to lose both our vice chairman and secretary. At this time, I would like to introduce our new vice chairman, Frank Beighley, roadway engineer, St. Louis–San Francisco Railway, and our new secretary, L. J. Deno, division engineer, Chicago & North Western Railway. Mr. Beighley is also chairman of our Subcommittee 6, and Mr. Deno is chairman of Subcommittee 8.

Mr. President, this concludes the report of Committee 1.

President Woolford: Thank you, Mr. Harris. Your committee again, with the cooperation of the Engineering Division research staff, a number of railroads, and several colleges and universities, continues to carry forward a wide range of projects of great value to our members and the railroads. For this, we are greatly indebted.

And our thanks to you, Mr. Hinueber, for your highly interesting talk on the asphalt treatment of ballast.

Mr. Harris, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Rail

[For report, see pp. 829–896.]

[President Woolford presiding.]

President Woolford: If our Committee 4—Rail, will now come to the platform, we would like very much to hear their report. The chairman of this committee, as you know, is L. S. Crane, until recently mechanical research engineer, and now assistant chief mechanical officer of the Southern Railway System, at Washington, D. C. I will be pleased if Mr. Crane and the other members of his committee will come promptly to the platform and present their report. I don't know how this committee is going to get in comments on all of its assignments as set forth in the program, along with its special feature, in the 35 min allotted to it, but this committee has done it before and I am sure it can do it again. It is all the time we can give them this morning, so I will have to ask Mr. Crane to try to push his report through, even though there are really many interesting subjects that his committee is handling this year. Mr. Crane, I will turn the podium over to you.

L. S. Crane: Mr. President, members of the Association, ladies and guests:

The report of Committee 4—Rail, will be found in Bulletin 556, beginning on page 829.

In the interest of time, we will present only one formal report, which has to do with our Manual material.

Before handling our Manual material, I would like to take the time, even though we are pressed to mention to you that we lost through death three members of our committee last year—E. E. Chapman, retired mechanical assistant, Santa Fe Railway, and a Member Emeritus of Committee 4; W. H. Penfield, retired chief engineer, Milwaukee Road, past director and past treasurer of the AREA, and also a Member Emeritus of Committee 4; and Edward Wise, engineer maintenance of way, Louisville and Nashville. Memoirs to these men appear with our printed report.

Assignment 1—Revision of Manual.

Chairman Crane: The report on Assignment 1 will be presented by Subcommittee Chairman W. J. Cruse, engineer maintenance of way, Great Northern.

W. J. Cruse: Your committee submits the following recommendations with respect to Chapter 4 of the Manual:

Pages 4–1–16 to 4–1–19, incl., Design for Track Bolts and Nuts: Reapprove with the following revisions:

Eliminate provision for 1¼-in diameter track bolts and nuts from Table 1, page 4–1–17; Table 2, page 4–1–18; and Table 3, page 4–1–19. I move that these recommendations be adopted.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Cruse: Pages 4—2–15 to 4–2–18, incl., Specifications for Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts, and Carbon-Steel Nuts: Reapprove with the following revisions:

Withdraw all data pertaining to alloy steel for track bolts, as follows:

On page 4–2–15, eliminate in the title the words: "And Alloy-Steel."

Eliminate in Art. 1, Scope, the words: "and alloy-steel."

Eliminate in Art. 3, Chemical Composition, the column headed "Alloy-Steel," and the note reading as follows: "The type of alloy to be used shall be agreed upon between the manufacturer and the purchaser."

Eliminate in Art. 4, Ladle Analysis, Par. (b), the following: "also any alloy element used."

On page 4–2–16, eliminate in Art. 6, Tension Tests, the column headed "Alloy-Steel."

Eliminate in Art. 8, Bend Tests, all of Par. (b)

On page 4–2–17, eliminate in Art. 9, Strip Test, the column headed "Alloy-Steel 115,000 Psi."

On page 4–2–17, Art. 9, Strip Test, eliminate reference to 1¼-in bolt.

On page 4—2–18, change Art. 13, Par. (b), to read as follows:

"(b) Wrench turn fit.—The nut shall have a free fit for at least two threads in starting on the bolt. When engaged for the thickness of the nut plus two threads, the nut shall show the following minimum and maximum resistance, and for the remainder of the screw length shall not exceed the maximum resistance to turning as expressed in pounds pull applied to the end of a 24-in wrench."

[The next two recommended editorial changes were not included in Bulletin 556.]

On page 4–2–18, eliminate in Art. 14, Marking, Par. (a), the following: "together with the initial A if alloy bolts."

Eliminate in Art. 14, Marking, Par. (b), Item 2. Material (carbon or alloy), and revise Item 3 to read Item 2, and Item 4 to read Item 3.

I move that these recommendations be adopted.

[The motion was duly seconded, put to a vote, and carried]

Mr. Cruse: Add to the Miscellaneous Part of Chapter 4 the data on shells and related gage corner developments shown on pages 833 and 834 of Bulletin 556. I so move.

[The motion was duly seconded, was put to a vote and carried.]

President Woolford: Thank you, Mr. Cruse. You have made a very excellent presentation.

Chairman Crane: Our feature speaker this morning really needs no introduction to you. He is a frequent speaker before the Association. It is my pleasure to present C. J. Code, assistant chief engineer—staff, of the Pennsylvania Railroad, who will speak on the subject, Wheel Load, Wheel Diameter and Rail Damage. Mr. Code.

Wheel Load, Wheel Diameter and Rail Damage

By C. J. Code

Assistant Chief Engineer—Staff, Pennsylvania Railroad

Mr. Chairman, Mr. President, ladies and gentlemen:

The other day when we had the symposium on standardization, one of the speakers, I think it was Norman Mochel, said something about keeping codes in perspective. Well, I don't think he was talking about me, but maybe before I wind up this subject today, you may think you need to keep this code in perspective. On the other hand, I think there are some things that we all need to keep in perspective, that is, to take a distant view and see the whole picture.

1. Study by Two Committees

The subject of relation of wheel diameter to permissible wheel load is an assignment of the Joint Committee on Relation Between Track and Equipment, AAR. The subject of investigation of shelly rail failures is an assignment of the Rail committee, American Railway Engineering Association. The two subjects are closely tied together.

The Rail committee investigation of shelly failures has been going on for 18 years. I have not been able to find the exact date on which the Joint Committee was given its assignment; however, it is at least 16 years old.

The Joint Committee on Relation Between Track and Equipment is, as you may know, composed of four members from the Engineering Division and four members from the Mechanical Division, AAR. The Subcommittee on Shelly Rail is, of course, composed of members of the Rail committee.

I would like to point out to you some of the mile stones which have been passed in this dual investigation.

2. Mathematics and Mechanics

The mathematics and mechanics of stress in the rail head as it is related to wheel diameter and wheel load is fully covered in a report by Professors Thomas and Hoersch under date of July 15, 1930, entitled "Stresses Due to the Pressure of One Elastic Solid Upon Another" and published in Bulletin 212 of the Engineering Experiment Station, University of Illinois. These gentlemen made a mathematical analysis of the subject based on the theory of elasticity and then proved their result by a laboratory test. The report covers 54 printed pages and the mathematics are quite complicated, including partial differential equations, elliptic integrals and so on, which are over the heads of most practicing railroad engineers, including myself. Nevertheless they came up with an empirical formula for the shear stress in the rail head with varying wheel diameter, wheel contour and wheel load, which is comparatively simple and easy to handle with logarithms or with a log log slide rule. This formula, which appears on page 48 of the Bulletin, I will show you later on a slide. In allowing for the hollow worn tread of the wheel it is necessary to use another formula which is more clearly set forth on page 839 of Vol. 39 of the AREA Proceedings for 1938.

The mathematics of determining how stress varies with wheel load and wheel diameter is thus established as the first mile stone. Various criticisms have been made of the application of this formula to the rail problem, one being that the formulas are true only within the elastic range, whereas the rail and wheel situation involves stresses within the plastic range. Another is that the rail is work hardened by the rolling wheel and, therefore, its mechanical and elastic characteristics immediately beneath the wheel load are changed. These are valid criticisms and probably account to some extent for the fact that the results of the work of Thomas and Hoersch has not been applied as promptly or directly as might be to the rail-wheel problem. Nevertheless, nothing better has been presented, and the results of further tests of a practical and laboratory nature in the past 18 years seem to indicate that while these formulae may not apply exactly in the plastic range they still cover the situation in a general way. At least, they apply to the situation up to the point where the plastic range is reached. They have been used by the American Iron and Steel Institute in arriving at its recommendation as to the maximum load of wheels of various diameters. This recommendation, first published in 1940, varies from 650 lb to 800 lb per inch of wheel diameter, depending on the class of wheel.

Unfortunately, this recommendation was worded so as to apply only to locomotives, tenders and passenger cars, and is not considered by our mechanical people to apply to cars in freight service.

If one applies these formulas to new wheel on new rail, or new wheel on worn rail for that matter, one quickly arrives at the conclusion that the stresses under normal

wheel loads, as we have known them in the past 30 years, are beyond the elastic limit. If one applies them to worn wheel on worn rail, where the rail and wheel contours fit more closely, one arrives at stresses within the elastic limit.

3. Review of Reports of Subcommittee on Shelly Rail

Dropping theory for the time being and going into more practical matters, in 1942, a subcommittee of the Rail committee with the assignment "Investigate Causes of Shelly Spots and Head Checks in Rail Surfaces for the Purposes of Developing Measures for their Prevention" began its work. Its first report was published in 1943. It included the results of inspection trips on the Norfolk & Western and the Chesapeake & Ohio, the examination of failed rails at the University of Illinois by Prof. Cramer, and the first work in the rolling-load tests to produce shelly rails.

By the time of the 1944 report, Prof. Cramer had developed his cradle-type rolling-load machine, in which he was able to produce failures very closely corresponding in appearance and geometry to the shelly rails developed in the field, using a 50,000-lb load on a 33 in wheel, and in approximately 1,000,000 cycles of loading. This was accomplished by a machine which changed the angle of contact between the wheel tread and the rail surface at each stroke, varying from level to 5-deg off level, and repeating this cycle once for every 180 cycles of the rolling-load machine.

The annual reports of the subcommittee from 1944 to date bring out the following information:

1. The use of rail and flange lubricators on curves accentuates shelling, and by shutting them off, the rail may be worn away fast enough to materially reduce head checking, flaking and shelling. You pay the price in curve-worn rail.

2. The use of relay rail, work hardened under lighter traffic at another location, generally has not been found to be too beneficial. Nevertheless, some roads find it economical to use relay rail on curves where shelling is a serious problem.

3. Normalizing relay rail is of no benefit.

4. Three percent chromium rail is beneficial but is neither practical nor economical.

5. The amount of cant—level, 1 in 40, or 1 in 20 has no noticeable effect.

6. Strain gages mounted on the rail end showed high residual strain, although no dynamic stresses over the yield point were measured. It is assumed that there were stresses beyond the yield point elsewhere in the rail head. The suggestion here appears first (1945) that shelling may be the result of exhausted ductility due to excessive plastic flow. A study of residual stresses by Prof. Norton at M.I.T. produced nothing of practical value.

7. For economical rail life on curves with shelling, transposition of the rails is beneficial.

8. A study of the chemistry of a large number of heats of rail, some of which shelled and some not, showed no trend connected with chemical analysis except to the extent that greater surface hardness was produced.

9. A study of curvature, speed and superelevation showed no definite trend.

10. The new rail sections, 115, 132, 133, 140 and 155 adopted in 1947, with their improved head contour, show some benefit in reducing the rate of shelling, but do not prevent it.

11. In 1949 Prof. Cramer reported that "a combination of high shearing stresses and flow of metal toward the gage side eventually starts a horizontal crack in the weakest spot of the steel", and also stated "It should be recognized that shelling cracks are caused primarily by the heavy bearing pressure of car wheels on a small area of con-

tact, which produces internal shearing stresses and flow that exceeds the capacity of the steel to withstand such stresses."

12. Control-cooled rail, suspected by some of being the culprit, was tested on the Pennsylvania Railroad vs. non-control-cooled rail from the same heat, and no difference in shelling was discernible.

13. Mr. Magee's measurements with strain gages on the rail web analyzed as to location of the centroid of pressure on the rail head indicated that it varied from the center of the rail to 1½ in from the center line, averaging about 0.7 in from the center line for cars. This was on a 6-deg curve.

14. Favorable results have been reported almost universally on heat-treated rail. It retards shelling and may give anywhere from 50 to 200 percent increase in life when shelling on the high rail and crushed head on the low rail are problems. It does not eliminate shelling under severe conditions. Its cost is about 60 percent more than standard rail.

15. Battelle Memorial Institute, one of the outstanding research organizations in the world, studied the shelly problem under AAR & AISI sponsorship from 1948 to 1954. While their studies were of value to us in understanding the mechanism of failure, their most practical conclusion referred again to the benefit of stronger steel, specifically heat-treated rail. They also said in their final report "The Hertz equations (basis of work of Thomas & Hoersch) and this work on mild steel and silver chloride suggest, in agreement with previous work, that smaller wheel loads or larger diameter of wheels would be quite helpful."—"It appears that plastic deformation may be the important culprit. It would appear that factors which would limit plastic deformation would also extend rail life."

16. Chrome–vanadium rail showed beneficial results somewhat similar to those with heat-treated rail, but it developed other faults which render its use undesirable.

17. University of Illinois torsion fatigue tests developed (1957) that the endurance limit of rail steel in completely reversed shear is 37,000 to 40,000 psi, a factor of later significance in connection with Dr. Frocht's reports.

18. The Pennsylvania Railroad reported a study of plastic flow of metal in the rail head, using brass pins to show the degree and direction of flow metal. It was concluded from these tests that the flow of metal on the top gage corner is toward the gage side; that it extends to a depth of ¼ to ⅜ in below the rail surface; that it extends back to the edge of the center arc and beyond; and that the deformation is positive evidence of shear stresses well beyond the yield point of rail steel.

19. Bethlehem Steel and U. S. Steel studied the hydrogen level in modern rail steel, their tests failing to show the presence of hydrogen in any significant amount.

4. Work of Dr. Frocht

Dr. Frocht presented a report in 1954 and again in 1959 on his studies by the photoelastic method. His last report is the most significant. He concluded that shear on one plane is plus or minus 35,000 psi, representing complete reversal, and that on another plane is zero to 54,000 psi. After discussing the stress situation and the possible causes of failure, Prof. Frocht concludes "that a 30,000-lb load on a 33-in wheel would seem sufficient to put the rail in a state of incipient failure."

Altogether about $250,000 has been spent by the AAR and the AISI in study of this problem. Amounts spent by individual roads and steel companies will materially increase the total.

A 30,000-lb load on a 33-in wheel is above the present normal load of 26,250 lb; however, when one increases this load 50 percent to allow for impact, a situation which is known to occur very frequently in service, one gets a load of 39,375 lb on a 33-in wheel, well above the load which Prof. Frocht indicates is sufficient to cause damage. On the other hand, if we would take Prof. Frocht's 30,000-lb load and divided it by a factor of 1½ to allow for 50-percent impact, we get a load of 20,000 lb on a 33-in wheel, or 607 lb per inch of wheel diameter, well below the loads now in use.

5. Earlier Analysis by Robey, Magee and Code

Prior to 1945, three individuals to my knowledge, made studies on the limitation of wheel load to limit damage, using the Thomas and Hoersch report as the basis of their work. These were W. E. Robey on the Santa Fe, G. M. Magee and myself. Each one of us separately came to the conclusion that to avoid all damage to the rail head from wheel loads would require a limitation well below 800 lb per inch of diameter, with a load on a 33-in wheel not more than 24,000-lb, and other diameters in proportion. I for one, concluded, and I think the others reached similar conclusions, that such a limitation was not practical in view of the existence of several hundred thousand cars with 26,250 lb on a 33-in wheel.

6. Action of Joint Committee on Relation Between Track and Equipment

The Thomas and Hoersch report, the studies at the University of Illinois, at Battelle Institute, by Dr. Frocht, the Pennsylvania Railroad's study on plastic flow and the practical investigations in the field have all been available to the Joint Committee on Relation Between Track and Equipment. When this committee was asked in 1958 to make a recommendation on the limitation of wheel loads for diesel and turbine locomotives, it reached the conclusion that sufficient study had been given the subject to justify a recommendation with respect to both cars and locomotives, and the recom-

Recommendation of Joint Committee on Relation Between Track and Equipment

April 29, 1959

Maximum Load on Wheels of Various Diameters

Nominal Wheel Diameter	Lbs. per Inch	Wheel Load
33 inches	800	26,400
36 "	810	29,200
38 "	820	31,200
40 "	825	33,000
42 "	830	34,900

Exceptions to be permitted for a limited number of cars for heavy loads which shall be subject to approval by Mechanical Division, A.A.R.

mendation was first made to limit wheel loads to 800-lb per inch of diameter. Review by Mechanical Division committees developed some opposition to this, and a modified recommendation was adopted, which was based on allowing the same stress in the rail head for wheels of other diameters as is caused by the 26,250 lb load on a 33-in wheel. This table, which allows a shearing stress of 50,000 psi under a wheel load increased 50-percent for impact and based on the condition of worn wheels on worn rail, gives the following limitations:

For 33-in wheels—26,400 lb
" 36-in wheels—29,200 lb
" 38-in wheels—31,200 lb
" 40-in wheels—33,000 lb
" 42-in wheels—34,900 lb

After some further maneuvering, this was put before the Mechanical Division, AAR for letter ballot in the summer of 1959. The vote, I am told, was approximately 60-percent affirmative and 40-percent negative; however, the negative votes included several important railroads, and the subject was referred by the General Committee back to the Car and Wheel Committees of the AAR for further study and recommendation.

An interim recommendation has been developed to require 36-in wheels or larger under all cars of over 70-ton capacity up to 90-ton capacity; that is, 210,000 lb on the rail up to 251,000 lb on the rail.

This recommendation, in my opinion, does not go far enough. We have reasonably good evidence that cars with 251,000 lb on eight 36-in wheels cause damage more rapidly than do our present cars with 210,000 lb on eight 33-in wheels. According to the table recommended, it takes eight 38-in wheels to properly carry this load. A satisfactory design of 38-in wheel with accompanying truck and underframe for the 251,000-lb car will go a long ways toward resolving the problem.

7. What Benefit Will Result?

There is a current misconception that this proposal to limit wheel loads will cure our present problems of rail damage. Nothing could be farther from the truth. Our present rail damage is resulting from wheels which are within this limitation. All that it is hoped to accomplish by limiting wheel loads is to avoid the accumulation of large numbers of cars with wheel loading in excess of that we now have, with resultant accelerated rail damage, and in this connection, I want to show you four slides. The first shows, for the information of those who may be interested, the formulas used in calculating the shear stress in the rail head due to the concentrated wheel load. The second is a photograph showing several detail fractures from shell developed in the most modern and heaviest rail sections, under heavy traffic including large numbers of cars loaded to the present generally accepted load of 26,250 lb on a 33-in wheel. The third and fourth are attempts to show by a curve the relationship between wheel load per inch of wheel diameter and the life of rail until heavy shelling or detail fractures from shell occur. It is laid out in the form of a standard "stress number of cycles" curve on a semi-logarithmic scale. Two points are shown from Pennsylvania Railroad experience; one at a location on our Altoona District where failures of this type have developed in 155-lb rail within its first 10 years of service. These are the failures illustrated on the previous slide. The second, point "C" in this chart, represents another location where, with the same wheel loads but fewer cycles, no failure has occurred, although plastic flow was found. Two other points represent the experience on other roads which I prefer not to identify, one where with 251,000 lb on 33-in wheels, no failures of this

$$T = \frac{1}{2} \frac{23,500}{\left(\frac{R_1}{R_2}\right)^{.271}} \times \frac{P^{1/3}}{R_2^{2/3}}$$

(University of Illinois, Engineering Experiment Station, Bulletin 212, July 15, 1930, Thomas & Hoersch)

$$P = \left(\frac{2\ T R_2^{2/3} \times \left(\frac{R_1}{R_2}\right)^{.271}}{23,500} \right)^3$$

T = maximum shearing stress.

P = load.

R_1^* = larger of two radii = 35.5" for 11.5" rail head radius = Rr
17" radius of hollow in wheel tread = Rh

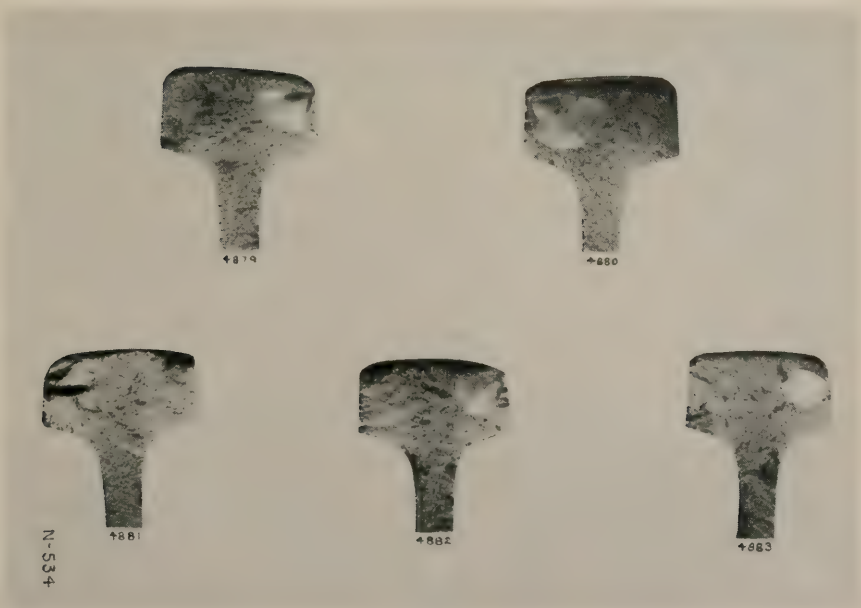
R_2 = smaller of two radii = 16.5" for 33" wheel.

*Where $R_1 = R_r' = \frac{Rr \times Rh}{Rh - Rr} = \frac{11.5 \times 17}{17 - 11.5} = \frac{195.5}{5.5} = 35.5"$

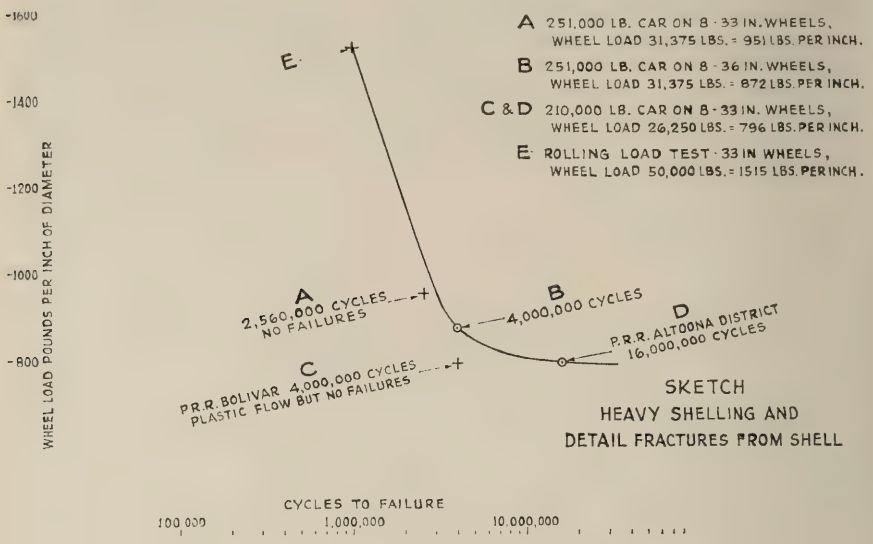
(AREA proceedings Vol. 39, 1938 page 839)

Formulas for Calculation of Shear Stress in Rail Head Under Wheel Load

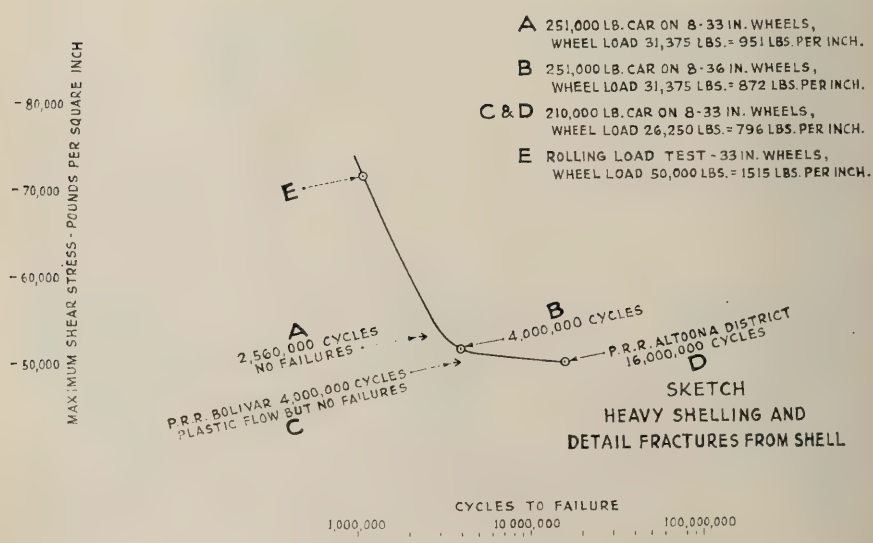
Slide 1



Slide 2



Slide 3



Slide 4

type have developed, but apparently the rail has not been in track long enough under severe conditions to develop these failures. The fourth point, "B" on the chart, represents experience of another road with 251,000 lb on eight 36-in wheels, where in 4,000,000 cycles of loading, failures have developed. Near the top of the chart is shown a point which represents Prof. Cramer's tests on the rolling-load machine, with 50,000 lb on a 33-in wheel. The whole assumes the form of a curve similar in shape to the standard stress, number of cycles curve used in fatigue studies. The shape of the curve in the vicinity of the 50,000 psi stress line indicates that a small increase in stress may result in a very marked shortening of rail life; for example, with the present loading, we have 16,000,000 cycles. Moving up to a stress of 50,500 psi drops the life back to 8,000,000 cycles, or half that now developed. At the "B" point with 51,400 psi, we have only one-fourth the life.

It can thus be seen that while rail stress of this type increases only in proportion to the cube root of the load, the life of the rail up until the time failure occurs, decreases very sharply for any small increase in stress. On the other hand, the chart shows that, if only a small number of cars are to be moved, such that the total number of cycles during the normal life of the rail will be a million or less, rather high loads per inch of wheel diameter can be handled without noticeable damage.

8. Conclusion

It behooves all of us to use our influence on the Mechanical Division representatives from our own railroads to have the recommendation of the Joint Committee on Relatino Between Track and Equipment approved and put in effect. [Applause]

Chairman Crane: Thank you, Mr. Code.

Mr. President, that concludes the report of Committee 4.

President Woolford: Thank you, Mr. Crane. Your committee each year, with the cooperation of Mr. Magee's staff, Professor Cramer, and the rail producers, develops and presents information which is of great value to our members and to the railroads, and we all make a serious mistake if we do not digest thoroughly your reports.

And thank you, Mr. Code, for further impressing upon us the importance of this matter of not overloading the running surface of the rail with excessive wheel loads. As chairman of the AAR Joint Committee on Relation Between Track and Equipment, you have done a most effective job in bringing about recommended limits of loading, and in bringing this matter to the attention of the Mechanical Department officers of our railroads. This is a tremendous problem but I am certain sound thinking will prevail. Thank you again.

Gentlemen, it is my opinion that when such an efficient committee as the Joint Committee that Mr. Code heads up, which includes members from the Mechanical Division, comes up with a recommendation, we should certainly take due cognizance of it and give it due consideration. The best brains of both groups have made this study and come up with what I think is a very logical recommendation. I think after you heard Mr. Code's talk this morning, you will not regret having elected him junior vice president.

Mr. Crane, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Continuous Welded Rail

[For report, see pp. 897–931.]

[Presiding Woolford presiding.]

President Woolford: We will next hear from one of our committees dealing with a matter of increasing interest and importance on the railroads, our Special Committee on Continuous Welded Rail. I will be pleased if members of that committee will take places here at the platform promptly. The chairman of this committee is F. L. Rees, acting regional engineer, Santa Fe, at Los Angeles.

Gentlemen, we are nearing the end of our morning session as far as committee reports are concerned. True, we are a little bit behind our schedule, not too much, but again I want to make the floor available to you and remind you again that this is your Association, your meeting. Participation in the meeting is, in my opinion, most desirable. We gain more from participating than just sitting back listening.

Mr. Rees, I will turn the podium over to you.

Chairman F. L. Rees: Mr. Chairman, members and guests:

After mushing over here this morning, I'm sure both you and I are ready to go back to the sunshine of the Golden State.

President Woolford: Well, I've tried to tell them that in the State of California we never have snow like this.

Chairman Rees: This committee's report may be found in Bulletin 556, starting on page 897. Regretfully, I must report the passing of two of our active committee members in 1959: Edward Wise, engineer maintenance of way of the Louisville & Nashville, and R. J. Gammie, retired chief engineer of the Texas & Pacific.

The Special Committee on Continuous Welded Rail was organized in 1950 for a comprehensive study of welded rail. The committee has collected information on all aspects of welded rail, its utilization, benefits, and limitations, and has disseminated this knowledge to the membership with the hope that such knowledge will enable engineering officers to present to management sound opinions regarding welded rail.

Investigation by the AAR Research Center has convinced many roads that the use of welded rail is feasible. Over 1 percent of the total mileage in the United States at the present time is welded rail. Admittedly, this is a small portion of the total mileage, but it shows that the use of welded rail is beyond the experimental stage.

The committee presents progress reports as information on four of six assignments. In 1961, recommended practices will be presented to the membership for approval and adoption.

Assignment 1—Fabrication.

Chairman Rees: The report on Assignment 1 will be presented by R. A. Shaw, assistant engineer, Pennsylvania Railroad, Altoona, Pa.

R. A. Shaw: The report entitled "Tests to Determine the Effect of Removing the Bulge from the Bottom of the Rail Base on the Strength of Acetylene Pressure Butt Welds", made by the AAR Research Center in late 1957 at the request of the Chicago & North Western Railway, is included in our report as Appendix A. It would appear from the test results that there is no appreciable difference in the strength of the acetylene pressure welds whether the upset metal is left on the bottom of the base or removed by grinding.

At the request of the Special Committee on Continuous Welded Rail, the AAR Research Center made a study of the possible effects on acetylene pressure butt welds

of eliminating the normalizing process that has been generally used. This report, included as Appendix B, indicates that the normalizing process used on the test specimens resulted in no appreciable difference in the strength of the weld.

The Research Center authorized the Armour Research Foundation to study "Bonding of Rails" for one year. This investigation, report on which is included as Appendix C, included study of end clamping pressure, rail joint heating, and filler materials. It recommended further investigation of the metal fiber shim brazing technique.

These reports, including the appendices, are submitted as information.

President Woolford: Thank you Mr. Shaw. Your report will be so received.

Assignment 2—Laying.

Chairman Rees: The report on Assignment 2 will be presented by Subcommittee Chairman E. J. Brown, chief engineer, Burlington Lines.

E. J. Brown: Again this year the tabulation of miles of continuous welded rail in track shows a substantial increase in such mileage over the previous year. There is now approximately a total of 3263 miles of continuous welded rail in track.

Several methods of laying continuous welded rail have been considered by the subcommittee, and significant in the report is a description of a typical dual organization of a rail laying gang that averaged four quarter-mile strings each in an 8-hr day.

The subcommittee hopes during the coming year that a more detailed report on other phases of laying will be considered, such as a further review of gang organization, buffer rails, practice in laying across bridges, etc.

Assignment 3—Fastenings.

Chairman Rees: The late Mr. Wise was chairman of Subcommittee 3. With his passing, the subcommittee was reorganized, but is unable to present a report at this time. Next year, under the leadership of D. T. Faries, chief engineer, Bessemer & Lake Erie, the subcommittee hopes to recommend anchorage patterns for adoption.

Assignment 4—Maintenance.

Chairman Rees: The report on Assignment 4 will be presented by Subcommittee Chairman E. P. Hackert, division engineer, Denver & Rio Grande Western Railroad.

E. P. Hackert: Your subcommittee submits a progress report which appears in AREA Bulletin, Vol. 61, No. 556, February 1960, as information. The information in this report was obtained by submitting questionnaires to some 30 Class I Railroads on maintenance of continuous welded rail, repair of major and minor derailment damage, driver-burned rails, internal defects, curve-worn rail, and pull aparts. The questionnaire also covered such items as maintenance of joints, plain and insulated, maintenance of gage, periodic inspection of welds, methods of surfacing, tie renewals, reballasting, etc.

Since replies indicated that methods of dealing with these maintenance problems varied widely, it was not felt that any recommendations for standards of maintenance should be made at this time.

It is the intention of your subcommittee to further pursue this assignment by dividing the subcommittee into several groups and assigning to each of these groups one or two of the items which appeared in the questionnaire. In this way, it is hoped, we can explore each of the various items more fully with the hope that results of such investigation will allow us to make recommendations for standard practices of maintenance of continuous welded rail.

On behalf of Subcommittee 4 of the Special Committee on Continuous Welded Rail, I should like to extend our thanks to all the members of the Special Committee

for their candid criticism and constructive suggestions, which were most helpful in preparing the comprehensive questionnaire which made this report possible; and to all of those maintenance officers who were kind enough to complete the questionnaire and furnish such information as was used in this report.

PRESIDENT WOOLFORD: Thank you Mr. Hackert. Your report will be received as information.

Assignment 5—Economics.

CHAIRMAN REES: Subcommittee Chairman W. J. Cruse, engineer maintenance of way, Great Northern, will present the report on Assignment 5.

W. J. CRUSE: This past year, your Subcommittee on Economics has reviewed the cost data furnished this committee by various railroads over the years, along with reviewing articles appearing the trade magazines concerning costs of welding continuous rail by both the gas pressure and the electric flash process. Cost figures for the reporting roads varied widely for both methods, and there was little or no correlation between the number of welds produced and the methods used.

The committee feels that this wide spread in welding costs is due principally to the varying methods used by the reporting roads in compiling their cost data.

The committee will ask in 1960 the cooperation of roads welding both 78-ft and continuous welded rail, to supply cost data for both the gas pressure and the electric flash process, specifying the weight of rail, whether new or second hand, if welding is performed by railroad-owned equipment, gas or electric, or by contract on railroad property or at a fixed location adjacent to one of the steel mills. This information will be requested annually for the next few years on prepared forms, detailing the various costs and separating them between labor and materials. These data will enable the committee to arrive at a more accurate welding cost for the various methods and procedures.

PRESIDENT WOOLFORD: Thank you Mr. Cruse. Your report will be received as information.

Assignment 6—Welding Second-Hand Rail.

CHAIRMAN REES: We have no report on Assignment 6. This is a new subject and H. F. Gilzow, process engineer of the Frisco at Springfield, Mo., will direct the activities of the subcommittee.

Mr. Woolford, this concludes the reporting of the Special Committee on Continuous Welded Rail. I wish to thank all the subcommittee chairmen for their work this past year in devoting their time so this committee could present information to the membership; to Mr. Woolford for his advice, on his visits to our meetings, which was accepted in the spirit in which it was given; and to Neal Howard, without whose guidance and direction no report would have been possible.

We have two special features which I hope will be informative and entertaining. The first film deals with a unique method of unloading welded rail, perfected on the Denver & Rio Grande Western. The second film illustrates a method of loading welded rail utilized by the Santa Fe.

[The motion pictures were shown with comments as follows]:

PRESIDENT WOOLFORD: Mr. Rees, you might want to explain something here. It looks as if these cars have rollers and keepers. In the first picture, from what I could see, it didn't look as if there were any rollers on the cars. The rails appeared to be loaded too close together to have rollers.

Chairman Rees: I am not certain about that. Are there rollers on your cars, Earl? You don't use rollers? Well, the rollers are maybe a refinement.

President Woolford: That is a matter that makes the use of continuous rail a little expensive. If you don't need rollers, you can use ordinary freight cars. If you need rollers, you have to have special equipment.

Chairman Rees: Well, we are not as progressive as the Rio Grande, because we tried it both ways, and we didn't have very good luck without the use of rollers.

President Woolford: I just thought that was something that the membership might like to have cleared up.

Chairman Rees: Well, we have tried it without rollers.

President Woolford: Gentlemen, this was a very efficient operation. It just happened your President was there when this picture, or one like it, was taken, and I can assure you Mr. Rees had a most efficient operation lined up for loading welded rail to take it to another location. I think Mr. Breeder was a little bit scared, when he let the committee go down there, that it wouldn't work out, but it really worked out perfectly.

Chairman Rees: Thank you for those kind words. I might mention that after the crews got a little more familiar with the operation, we could load a train in about 2½ hr with 8 men.

Mr. President, this concludes the reporting of the Special Committee on Continuous Welded Rail.

President Woolford: Gentlemen, it surprised me that there was no questioning from the floor on this continuous welded rail report. Last year, if you remember, there was heavy discussion. Maybe you know our program is running a little late and everyone is satisfied with continuous welded rail and there are no questions from the floor.

C. J. Geyer [C&O, retired]: I don't want to disappoint you. I have been wondering if the committee has given any consideration to the miles of rail that a given railroad should lay per year to justify the investment in rolling stock and equipment as shown here.

Chairman Rees: No, I don't think that point has been studied. On the Santa Fe we try to lay about 270 miles in our program.

Mr. Geyer: Two-hundred-seventy miles per year of welded rail?

Chairman Rees: Yes, sir.

Mr. Geyer: Do you mean by that, then, that each railroad ought to lay that much rail in order to justify the investment?

Chairman Rees: I think that is up to the individual railroad. We have made no studies on the economics involved, as to just what is the optimum amount to lay to justify the investment, but that is a subject we can look into.

Mr. Geyer: That is all I have to bother you about right at the moment.

President Woolford: Mr. Geyer, that was one of the questions I brought up in connection with one of the pictures being shown, the method for loading the rail on cars and moving it over line of road. Some railroads can't take certain cars out of service and equip them specially for handling welded rail. If the Rio Grande has been successful in loading, moving and unloading rail with ordinary flat cars, without special appliances, I think they have achieved a very sound practice.

The committee didn't see fit to make a report at this time on the welding of rail as is being done on the Southern Railway, but I was fortunate enough to have Mr. Echols and Mr. Brosnan invite me to come down and go over their plant. Gentlemen, I must say they are doing a wonderful job of welding rail and of moving it out on

line of road. They have some pretty fancy equipment in their operation. Undoubtedly, they have studied the cost of the equipment and have justified its purchase and use. I couldn't speak on that because I don't know.

Well, gentlemen, if there are no other questions from the floor on this most interesting report from the Continuous Welded Rail committee, I will thank Mr. Rees for his report. It is evident from the reports of your committee and the motion pictures shown that we are moving fast ahead in this matter of continuous welded rail, but with much, unquestionably, still to be learned. We shall continue to expect this most efficient committee, with the assistance of our AAR research staff, to keep us fully informed regarding all developments. I am sure we can count on this after seeing the chairman of this committee and its consist.

Mr. Rees, your committee is now excused with the thanks of the Association. [Applause]

Gentlemen, before I call the next committee to the podium. I would like to repeat that the hotel management has extended the check-out hour for everybody at the convention. It is a very nice gesture to our group and it will relieve a lot of pressure on our members who would have to rush to get checked out, especially with this bad weather we are confronted with.

Discussion on Track

[For report, see pp. 933–976.]

[President Woolford presiding.]

President Woolford: The final report on our convention program is that of a most important committee, Committee 5—Track, the chairman of which is Troy West, until recently engineer of track of the Union Railroad at East Pittsburgh, Pa., and now assistant to the chief engineer of that railroad.

I will appreciate it if Mr. West and the members of his committee will come forward at this time.

While Mr. West and his committee are coming up, I want to say again that expressions from members of the Association are welcome. Mr. West, I will now turn the podium over to you.

Chairman Troy West: Mr. President, members and guests:

First, I want to thank you for remaining to hear our committee report. It is the last but we hope not the least. We do thank you for remaining to listen to us and I hope your patience will be rewarded. At the same time I want to repeat what President Woolford has said, that I hope you will avail yourself of the opportunity to discuss, or ask questions from the floor about, any part of our report, particularly the panel discussion on standardization of track turnouts, which will be presented later on.

It is my sad duty to report to you that F. J. Bishop, Member Emeritus of Committee 5, died last Monday. Mr. Bishop joined the AREA in 1924. He served Committee 5 well, being chairman from 1951 to 1953. An appropriate memoir will be prepared.

Last year our committee reported to you on a very important assignment—Assignment 11—Economies to be Gained by the Railroads from the More Extensive Use of AREA Trackwork Plans. This year that subject is included in Assignment 3—Standardization of Trackwork Plans, which will be reported on later.

Our report is found in Bulletin 556, pages 933 to 976, incl.

Assignment 1—Revision of Manual.

CHAIRMAN WEST: Our first assignment, Revision of Manual, is conducted by R. G. Sproles, assistant chief engineer of the Louisville & Nashville. This committee is considering spectrographic testing in determining chemical analysis of steel for tie plates and steel track spikes, and their recommendation will be submitted to you later. Mr. Sproles, please stand and be recognized.

Assignment 2—Track Tools, Collaborating with Purchases and Stores Division, AAR.

CHAIRMAN WEST: Assignment 2 is conducted by C. E. Peterson, assistant engineer, Santa Fe Railway. His committee has designed a tee-handled drive spike extractor socket wrench to fit a standard ⅞-in-square drive spike head. They are now working on a design of the stem of the screw spike, and, when completed, specifications for both the wrench and the spike will be presented to you with drawings for your consideration. Mr. Peterson, please stand and be recognized.

Assignment 3—Standardization of Trackwork Plans, Collaborating with Signal Section, AAR.

CHAIRMAN WEST: The report on Assignment 3 will be presented later. [See page 1237.]

Assignment 4—Prevention of Damage Resulting from Brine Drippings on Track and Structures, Collaborating with Committee 15, and Mechanical Division, AAR.

CHAIRMAN WEST: Assignment 4 is conducted by W. E. Griffiths, chief engineer, Central Region, Canadian National Railways. This committee is continuing laboratory work with Mr. Magee and his staff on evaluating various inhibitors for adding to ice–salt mixtures in refrigerator cars to reduce the corrosive action of brine on track and structures.

Mr. Griffiths is not here, but I wish to thank him and his committee for the work they have done.

Assignment 5—Design of Tie Plates, Collaborating with Committees 3 and 4.

CHAIRMAN WEST: The report on Assignment 5 will be given by Subcommittee Chairman L. A. Pelton, district engineer, Pennsylvania Railroad.

L. A. PELTON: This report covers the service test of special 8- by 15- by 1-in thick tie plates with 1¼-in eccentricity on the Illinois Central Railroad near Dubuque, Iowa.

The special plates, similar to the AREA Plan No. 20, were reinstalled on the 6-deg curve in single main track, August 1955. Test construction consists of four test sections of two 24-tie track panels each. Section 1, the control section, has 13-in tie plates under both rails. Sections 2, 3 and 4 has the 15-in tie plates on the inner rail and the 13-in tie plates on the outer rail. Sections 1 and 2 have two cut spikes for anchors, Section 3 two lock spikes and Section 4, two Racor Studs for anchors.

Initial readings on the test were taken in October 1955, and repeated in 1956 and 1957. The latest data were taken in June 1959. During the 3.7-year service period the test track has carried 50.3 million gross tons of traffic, of which 29.4 million was eastbound.

On pages 946 and 947 of Bulletin 556 is a summary of tie plate penetrations and gage, curvature and elevation readings for the test period.

Results show that in Sections 2, 3 and 4 tie plate penetration of the 13-in plates on the outer rail has been greater than the 15-in plates on the inner rail. This same trend is also evident to a lesser degree in the control panel, where 13-in plates are used on both rails. When this test was installed it was assumed that due to ascending grade the westbound tonnage would operate below the equilibrium speed.

However, due to changing operating conditions, examination of penetrations on the control section would indicate a majority of the tonnage is operating above the equilibrium speed.

Although this test has been installed an insufficient length of time to make definite comparisons of the different installations, examination of the data indicates that those plates with the lock spikes as anchors are showing the least amount of tie abrasion. The studs are doing well on the 15-in plates on the inner rail but show no advantage over cut spikes on the outer rail. Nine hold-down spikes were found to be loose in Section 3 compared with 70 in Section 4.

During the last two year service period only Sections 2 and 4 have shown any appreciable amount of gage widening.

Even in this relatively short test period, it is apparent that the pressure on the outer rail is greater than originally anticipated. In order to obtain the results desired in this test, consideration is therefore being given to reversing the plates between the two rails in Sections 2, 3 and 4. This would place the 15-in special tie plates on the outer rail.

President Woolford: Thank you, Mr. Pelton. Your report will be received as information.

Assignment 6—Hold-Down Fastenings for Tie Plates, Including Pads Under Plates: Their Effect on Tie Wear, Collaborating with Committee 3.

Chairman West: The report on Assignment 6 will be given by the subcommittee chairman, J. S. Parsons, chief engineer of the Erie.

J. S. Parsons: Our report includes the results of an inspection of the test installations of tie pads and hold-down fastenings, etc., on the Louisville & Nashville Railroad as well as progress made with the AAR design of tie wear machines in the Engineering Laboratory at the Research Center. The tests, in general, are being conducted by your committee under the direction of the AAR research staff, particularly H. E. Durham, research engineer of track, who are developing information which we hape may prove conclusive within the next couple of years. During 1959, an inspection was made by the committee covering the L&N test section. The research staff, besides assisting with this inspection, checked test sections 35 and 36 having the Koppers' No. 16 tie sealing compound and supervised the alteration of two test sections, along with taking the base readings. This year detailed inspection and measurement of gage of the curves were omitted. No maintenance work was performed on the fastenings.

The revisions in the test sections during 1959 were in connection with Section 28 where 48 tire carcass pads, 3/16 in. in thickness and coated on both sides, manufactured by the Konvex Tie Pad Company of East St. Louis, Ill., were installed in the north one-half of Section 28 on the long 4½-deg curve south of East Bernstadt and in replacement of the Western Felt Works wool felt pads. These Konvex pads were placed on 24 new creosoted oak ties using new 14-in double-shoulder tie plates with two cut spikes each for line and anchor.

On Section 56, 68 Fabco pads with a new type of coating on the underside were installed on the 5-deg curve at East Bernstadt. Thirty-four pads on the north one-half

of the section are ¼ in thick, and the remaining 34 on the south end are ⅛ in thick. These pads replaced Fabco pads of similar thickness which were installed in June 1955 on new ties. The coating referred to is known as "Super-Seal" and has an improved formulation of asphalt applied over a rubber-based primer coat on the bottom side only.

During 1959, the first AAR design of tie-wear machine was operated 23 million test cycles in 20 separate tests. This included several short tests of tie pads on concrete ties. One test carried out on a new formulation resulted in its rejection for use in track. The second tie-wear machine of AAR design was built during the year as a duplicate of the modified machine in order to increase the capacity for testing pads and fastenings. The control test with a 7¾- by 14-in tie plate, four cut spikes and a short piece of creosoted oak tie were completed at the end of the year. The results of these tests indicate the machine will be satisfactory for the evaluation of tie pads, hold-down fastenings, etc.

In our previous reports, two types of ⅛ in thick pads were found failing and will not give a good service life under test conditions. Reference is made to the Dunne Rubber Company's molded rubber pads and the ⅛ in thick J–M laminated rubber-asbestos pads. There was also an indication that the Fabco ⅛-in thick pads may be too thin for test conditions. Last year's report listed the tie pads which were not satisfactory for the service conditions.

Your committee wants to take this opportunity to thank the L&N Railroad for its continued cooperation and assistance in making the investigations under test and also to extend thanks to the suppliers who have rendered assistance in many ways.

President Woolford: Thank you, Mr. Parsons. Your report will be received as information.

Assignment 7—Effect of Lubrication in Preventing Frozen Rail Joints and Retarding Corrosion of Rail and Fastenings.

Chairman West: The report on Assignment 7 will be presented by C. E. Peterson, assistant engineer, Santa Fe, in behalf of Subcommittee Chairman R. G. Garland, roadmaster, Santa Fe.

C. E. Peterson: Mr. President and gentlemen:

Our service tests of rail joint preservatives are continuing. We are studying protection of rail and fastenings from corrosion in tunnels. In the near future, preservative coatings will be applied to the exposed surfaces of rail and fastenings in 78-ft rail territory to develop a spray that will retard corrosion, especially in the weld area.

As a result of our several years' studies, it is desired to bring up to date references pertaining to rail joint preservation. Your committee submits the following recommendation with respect to Manual material on oiling track fixtures.

[Mr. Peterson then read the recommendations of the committee as printed on page 954 of Bulletin 556, and moved that they be adopted and published in the Manual.]

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Peterson: In the Specifications for Laying Rail, Manual pages 5–5–1 to 5–5–3, incl., your committee recommends deletion of the first paragraph under Sec. C, substituting the following:

"As the rail is laid, all joints shall be given a brush coat of a metal preservative in accordance with Art. 1a of Preservation of Track Fixtures, Part 5, this chapter." Mr. President, I so move.

President Woolford: The motion has been made and seconded. Is there discussion? I know you are not all doing what he has recommended. A lot of people don't

follow that practice. Does anyone want to argue about it or discuss it before we vote on the motion? Don't be timid. We would like to hear from you. Speak up. If you don't agree with the committee, say so.

[The motion was put to a vote, and carried.]

Assignment 8—Laying Rail Tight with Frozen Joints.

Chairman West: The report on Assignment 8 will be presented by Subcommittee Chairman J. B. Wilson, chief engineer, Georgia Railroad.

J. B. Wilson: Mr. President, members and guests: The subject "Laying Rail Tight With Frozen Joints" was given the Track committee in 1955, and the first report of the subcommittee was made the following year covering tight rail laid on the Louisville & Nashville near Chapel Hill, Tenn. Since that time, we have added two additional test sections, one on the Bessemer & Lake Erie near Grove City, Pa., and the other on the Erie Railroad near Crown Point, Ind.

Of the three test sections, the one on the L&N is the only one where the rail was laid, anchored and bolts tightened to the required tension at or near the mean average temperature. On the Erie test section, work was started near the average mean temperature, but during the laying period the temperature got well above the mean temperature. On the B&LE test section, rail was laid near mean temperature, but loss of bolt tension in the first month after laying was sufficient to permit considerable opening of joints with the relatively low temperature that prevailed during the period. We wish to call these facts to your attention as they explain the variation in charts incorporated in our report published in Bulletin 556.

On August 25, 1959, members of the subcommittee and a member of AAR research staff, together with representatives of the L&N, met at Chapel Hill, Tenn., and looked over our first tight rail test section near that station.

The tight rail at this location was laid in November 1953. It is on a tangent and is some 7/8 of a mile in length. Track is laid with 132-lb rail on 14-in tie plates, has 6-hole headfree bars, 1 1/8-in bolts, and is fastened to the ties with 5/8- by 6-in cut spikes. Compression clips are used as anchors, the clips being applied in three ways; the north section has clips on the field side on all ties except the joint and shoulder ties; the middle section has clips on the field side on alternate ties, except at joints, and the southerly section has clips in a like manner, except that they are on the gage side. Rails were not end hardened or chamfered, but the ends were milled.

The normal rail test section adjoining was laid at about the same time as the tight rail with same weight rail, tie plates and joints. This track is anchored with rail base anchors boxed on four alternate ties in each one-half panel, the same as the AREA recommended minimum anchorage for two-way traffic.

After some 77 million gross tons of traffic, we observed that the tight rail had a much better surface and line than the normal-laid rail. We were advised by L&N representatives that the tight rail had riding qualities much like welded rail and required much less maintenance than normal-laid rail. The only bad feature of the tight rail was the chipping of joints. During the 5 3/4-year period that the rail had been in service all but 51 of the 211 joints had been built up by welding. It was the consensus of those making the inspection that chipping had been accelerated because the rail ends were undercut too much in an effort to insure a tight fit at the top of the rail surface.

From our observation to date of the three test secions, it is apparent that tight rail must be laid near mean temperature and that almost perfect rail end matching is

necessary together with maximum slippage resistance in order to get good results from tight rail installations.

This is a progress report, and the subject will be continued.

PRESIDENT WOOLFORD: Thank you Mr. Wilson. Your report will be so received.

Assignment 9—Critical Review of the Subject of Speed on Curves as Affected by Present-Day Equipment, Collaborating with the AAR Joint Committee on Relation Between Track and Equipment.

CHAIRMAN WEST: Assignment 9 is conducted by L. H. Jentoft, assistant chief engineer of maintenance of way of the Erie Railroad.

This committee is making a critical review of a proposed formula for the spirals of curves. This formula involves coefficients which will be checked through test and more definitely developed in 1960. Mr. Jentoft, please stand and be recognized.

Assignment 10—Methods of Heat Treatment, Including Flame Hardening, of Bolted Rail Frogs and Split Switches, Together With Methods of Repair by Welding.

CHAIRMAN WEST: The report on Assignment 10 will be presented by Subcommittee Chairman J. M. Salmon, chief engineer, Clinchfield Railroad.

J. M. SALMON: This is a progress report, presented as information.

The service tests of simulated crossing units on the Milwaukee Road at Mannheim, Ill., are being continued by the AAR research staff. The installation is described in Vol. 56, 1955, page 878, and results are reported in each succeeding volume through Vol. 60, 1959. Results of the past year were published in Bulletin 556, February 1960.

A questionnaire as to repair by welding of rail frogs and split switches was circularized in 1959, replies being received from 35 railroads. As soon as this information is evaluated, it will be presented as information.

The committee is indebted to the Milwaukee Road and the sponsors of the various test units and welding techniques for their cooperation and assistance in conducting this investigation.

PRESIDENT WOOLFORD: Thank you, Mr. Salmon.

Assignment 3—Standardization of Trackwork Plans, Collaborating with Signal Section, AAR.

CHAIRMAN WEST: It is now my pleasure to introduce M. J. Zeeman, engineer of track design of the Santa Fe, who will report on Assignment 3.

M. J. ZEEMAN: Mr. President, Mr. Chairman, members and guests:

Your committee submits for approval as recommended practice and publication in the Manual (Portfolio of Trackwork Plans) Plan No. 980–60—Turnout and Crossover Data for Tongue Switch Construction for Use in Pavement, and the withdrawal of the previous issue of this plan, No. 980–54. A print of the recommended new plan is presented in Bulletin 556.

There are four plans of solid manganese steel tongue switches now in the Portfolio which your committee recommends be revised to bring them into agreement with new turnout plan No. 980–60. The proposed revisions are in the titles and the notes only, and while the revised plans are not presented in the Bulletin, a complete description of the changes in these four plans is given on pages 935, 936 and 937 of Bulletin 556. The four plans are Nos. 982–60, 987–60, 988–60 and 989–60 and supersede the previous issue of these plans.

Since the new plan and the revisions in the four other plans are closely allied we wish to handle them together; therefore, Mr. President, I move for adoption as recom-

mended practice and publication in the Manual (Portfolio of Trackwork Plans) new Plan No. 980–60 and the revision in titles and notes of Plan Nos. 982–60, 987–60, 988–60 and 989–60 as detailed on pages 935, 936 and 937 of the Bulletin, and the withdrawal of the previous issues of these five plans, being Plan Nos. 980–54, 982–55, 987–55, 988–55 and 989–55, respectively.

President Woolford: You have heard the motion and it has been seconded. Is there any discussion from the floor? I imagine most of you have read the report which Mr. Zeeman speaks about. It has been out for some time. It has been most excellently prepared and now is the time to ask questions on it if you have any. We have a man here at the podium who has the knowledge and he will be glad to answer any questions anyone has before we vote on this. Are there any questions from the floor?

[There being no questions, the motion was put to a vote, and carried.]

Mr. Zeeman: As stated in our printed report, while the Trackwork Portfolio contains plans of a variety of trackwork material, your committee has for the past year concentrated its efforts on submitting to you its recommendations for standard turnouts.

Our report relates in detail how the committee started its work on standardization. A special committee of five subcommittee members, with T. R. Klingel as chairman, was appointed as a procedure or steering committee to make recommendations to the subcommittee. The report of this special committee, being Appendix 3–b, formed the basis of our deliberations and finally resulted, with only a few minor changes, in the Track committee's recommendations to you.

Our recommendations are based mainly on the best possible combination of frogs, switches and guard rails now in the Portfolio into a few selected turnouts which could be made standard for general use, taking into consideration the extent of present use as well as economy.

Your committee recommends three standard turnouts for main-track, through-train movements, being a No. 20 turnout with 39-ft curved switch for high speed, a No. 15 turnout with 26-ft curved switch for medium speed, and a No. 10 turnout with 16-ft 6-in straight switch for low-speed movements. For yard and switch movements, we recommend two standard turnouts, a No. 8 turnout with 16-ft 6-in straight switch and a No. 6 turnout with 11-ft straight switch where limited space prevents using a No. 8 turnout.

Beginning at the top of page 938, our report shows in items 1 and 2 the five standard turnouts just mentioned, followed by items 3 to 15, incl., showing the construction or design details of the component parts of these five turnouts. We feel certain that everyone familiar with turnout construction understands from the descriptions given in these 15 items the design your committee is recommending as standard.

We propose to prepare complete turnout plans for the five turnouts recommended as standard, one plan for each turnout. Each plan would be complete, including switch, frog, guard rails, turnout and crossover data, typical rail layout, ties, etc. Such a plan would eliminate the necessity of consulting a great number of plans to get data for a complete turnout, required under the present system. Then each turnout plan would be followed by a detail plan of the switch, frog and guard rails. We also propose to place these five turnout plans with the supporting detail plans, suitably designated as standard plans and recommended practice, in the front of the Portfolio, and to place the remaining plans of turnout material in the back of the Portfolio as information, as it is not the intention to remove any plans from the Portfolio.

Having briefly outlined the main points about our proposals, it is thought that we may have an opportunity to bring out the reasons for selecting the particular turn-

outs and their design through a panel discussion; in a sense, anticipating and answering questions which could be asked in a discussion from the floor. We will conclude our report on standardization right after the panel discussion is finished.

Panel Discussion—Standardization of Track Turnouts

Mr. Zeeman: At this time I should like to introduce S. H. Poore, assistant engineer of the Chesapeake & Ohio Railway, who will act as moderator of the panel discussion on standardization of track work plans. Mr. Poore will introduce the members of his panel.

President Woolford: Gentlemen, so that you understand what Committee 5 is doing now, they are coming up with 5 standard turnouts, without exceptions. The No. 20, as Mr. Zeeman has stated, will have a curved point and will be good for high-speed railroads. But you must think of it also in terms of railroads that don't need this high speed. There are many other points that might be brought up. This is in the direction of standardization, and it is probably the first concrete move that has been made. But we want to adopt something that is acceptable to all American railroads and can be used as standards.

Think this through very thoroughly. The panel is here to answer any questions. You have men here who are capable of answering them. Don't be timid or hesitant. Make yourself known. If you are not ready for the committee to spend the time necessary to detail these plans, make it known.

S. H. Poore: The committee, as stated, has just started on a project to simplify special trackwork, that is, frogs, switches, and turnouts. Mr. Zeeman, chairman of Subcommittee 3 of the Track committee, has just presented the proposed program. This discussion of the proposal is intended to answer certain questions that may come to your minds as responsible engineering officers on your respective roads. You will recall from Mr. Zeeman's presentation that it is proposed to set up five different turnouts as recommended practice, placing all other turnouts now in the Portfolio of Trackwork Plans in the "as information" category. The five turnouts to be discussed by this panel would then constitute AREA recommended practice.

For the main line there are three turnouts, the No. 10 for low speed, the No. 15 for medium speed, and the No. 20 for high speed. For yards, Nos. 6 and 8 turnouts are proposed.

We have on the panel here at this time the several men we believe best qualified to discuss this subject. I will introduce them.

M. C. Bitner, manager of methods and cost control of the Pennsylvania, on my left.

F. W. Creedle, chief engineer, Trackwork Products, Railroad Products Division, American Brake Shoe Company, on my immediate right.

T. R. Klingel, chief engineer of the Minneapolis, St. Paul & Sault Ste. Marie Railroad, on the far right.

M. J. Zeeman, engineer of track design of the Atchison, Topeka & Santa Fe Railway, on the left.

I am S. H. Poore, assistant engineer of the Chesapeake & Ohio Railway.

And now for the questions. Why pick three main-line turnouts? Mr. Klingel, I believe, will be a good man to answer that one.

T. R. Klingel: To secure the maximum benefits of standardization, it was necessary to select the minimum number of turnouts that would fulfill the requirements for all typical locations. The committee concluded that three turnouts should be selected that would permit speeds which conformed with current signal practice for diverging route operation over high-speed, medium-speed and low-speed turnouts. The No. 20 turnout was selected as the high-speed turnout, the No. 15 as the medium-speed turnout, and the No. 10 as the low-speed turnout. It is our opinion that these three turnouts would provide adequate choice of permissible speeds to permit selection of the proper turnout to meet practically all requirements for main-line operation.

Moderator Poore: Thank you, Mr. Klingel.

Why No. 15 for medium speed and not a No. 16 or 14?

Mr. Klingel: The usual practice in this country at the present time is to allow speeds up to 35 mph with medium-speed signal indications for diverging routes. The No. 15 turnout with curved switch point permits speeds of 38 mph for lateral turnouts and 53 mph for equilateral turnouts. This turnout, therefore, complies very well with the requirement that it conform to the usual accepted speed for a medium-speed signal indication. The No. 14 turnout permits speeds of 34 mph. This speed is a little low for these medium-speed movements. Predominant diverging train movements would be at the maximum allowable speed, and the cost of maintenance where all trains operate at maximum speed through the turnout is much higher than where trains are operated at speeds somewhat below the maximum. The allowable speed for the No. 16 turnout is 40 mph, or only 2 mph greater than for the No. 15. The cost of the No. 16 is greater than for the No. 15, and the limited advantage of the No. 16 over the No. 15 does not justify the additional expense. For any program of standardization to be successful, it must be easy for the majority of roads to adopt. The committee determined that more roads were using No. 15 turnouts at the present time than were using either No. 14 or No. 16 turnouts. The No. 15 turnout could be adopted by the American railroads as standard with much less trouble and expense than would be involved in the selection of either of the other two turnouts. This was another factor that indicated the No. 15 turnout as the logical choice for a standard medium-speed turnout.

Moderator Poore: Well, now, why recommend curved switch points and not straight points for the No. 15 and 20 turnouts?

Mr. Klingel: The No. 15 and No. 20 turnouts are the medium-speed and the high-speed turnouts, respectively. Maximum allowable speed is the primary consideration in selecting these turnouts. The use of curved switch points permits operation at higher speeds than straight points, provides a better alinement for the diverging route and, therefore, a smoother ride, requires less maintenance because of the better alinement, and requires a shorter lead distance, which offests in part the additional cost of the curved switch. The committee is of the opinion that the additional cost is justified by the advantages in operation and maintenance, where maximum speed is such an important factor.

Moderator Poore: Why No. 6 and No. 8 turnouts for yards?

Mr. Klingel: Maximum speed is not a primary consideration in the selection of turnouts for yards. Here, the problem is to select turnouts that can be operated over at normal switching speeds, that have a reasonably short distance between the head-block and the clearance point so as to provide maximum track capacity with minimum cost, and turnouts that are not so abrupt in curvature as to require excessive maintenance. The No. 8 turnout is used extensively at the present time and the curvature, which was considered objectionable by some roads for operation with steam locomotives,

is no longer a problem with diesel locomotives. The length of lead is only 68 ft, which will permit good track capacity. Sharper turnouts would be more difficult to maintain and longer turnouts would be more expensive and would reduce track capacity unnecessarily. The No. 8 turnout is, therefore, recommended for all typical locations for yard and switch movements at slow speeds. Occasionally, other factors may dictate the location of the switch or the alinement of the track so as to make a sharper turnout necessary, the use of a No. 8 turnout being impossible or impractical. For these locations, the use of a No. 6 turnout is recommended. The No. 5 turnout is so sharp as to be impractical unless absolutely necessary, and such occasions are not frequent enough to justify an industry-wide standard.

Moderate Poore: Mr. Creedle, why are graduated risers recommended instead of uniform risers for the switches?

F. W. Creedle: Well, the cost of the complete switch with graduated risers is less than the cost with uniform risers, due mainly to the use of hook-twin tie plates with the former, instead of the run-off plates at the heel of the switch. In the case of the rigid heel block, the same block can be used for both right-hand and left-hand switches with the graduated risers, due to being level at the heel. That is a factor in the direct expense and storage expense also. The graduated risers are actually more generally used throughout the country than the uniform risers, and if you want to have a plate at the heel of the switch similar to the run-off plate, that can be obtained, which would make the cost of the two switches very nearly the same.

Moderator Poore: Why recommend undercut stock rails for curved switches and the conventional stock rail for straight switches? Mr. Klingel, I believe you can answer that.

Mr. Klingel: Curved switch points are bent so as to be parallel to the stock rail at the point. Undercutting the stock rail permits making the switch point thicker and stronger at the point than would otherwise be possible. The undercut stock rail is more expensive, but the increased life of the curved switch point more than justifies the additional cost. Straight switch points which meet the stock rail at an angle can be tapered sufficiently to provide adequate strength without undercutting the stock rail, so that the ¼-in point with the conventional stock rail is recommended as being more economical for the straight switches.

Moderator Poore: Mr. Zeeman, why a fully bolted heel block instead of the so-called floating heel?

Mr. Zeeman: The committee recommends a fully bolted heel block assembly, including shoulder bolts, because it makes a stronger heel joint. Also, it reduces maintenance expense in maintaining proper switch point clearance by its rigidity. Present-day improved rail anchorage has largely eliminated the former objections to the rigid heel joint assembly.

Moderator Poore: Why are flat switch rods recommended, Mr. Creedle?

Mr. Creedle: Well, the present AREA plans do not have a vertical rod. The committee felt that the side jaw clip would be most suitable for most of the locations, which would include, too, the greatest number of switches, and this would require the use of a flat rod. It ought to be pointed out, however, that the vertical rod is extensively used in this country on power-operated switches. I don't see any objection to anyone ordering a vertical rod if they wish to do so and I don't see how it would adversely affect the standardization program.

Moderator Poore: Mr. Klingel, why not use adjustable rail braces on all switches?

Mr. Klingel: Adjustable rail braces make it possible to maintain very close tolerance on the fit of the switch points and on the track gage, but they are more expensive,

consist of more parts, which complicates installation and maintenance, and require frequent inspections to maintain the required fit and to keep the bolts tight. For these reasons, it was not considered either necessary or desirable to adopt adjustable rail braces on switches for yard and switch track use.

Moderator Poore: Mr. Creedle, why abandon the use of 60-ft stock rail with 39-ft switch points?

Mr. Creedle: Well, the 39-ft stock rail has been used successfully for a number of years on the 39-ft switch point, and the principal reason for abandoning the 60-ft stock rail is the great difference in the total cost between the two. This includes not only a much higher cost for fabrication and shipment, installation and repairs, but also the higher initial cost of the rail from the mill. You would also have some higher cost in handling if this rail were welded at your own welding plant, because you would still have to undercut the rail and incur the machining and handling cost to and from the plant.

Moderator Poore: Why have both rigid and spring frogs for No. 10 main-line turnouts, Mr. Zeeman?

Mr. Zeeman: These two designs cannot be called alternates. Each type is designed for a particular use, largely determined by conditions as well as methods of train operation, and whether the traffic is predominantly over the main track or is more nearly equally divided. In the spring rail frog, the long spring rail design is preferred because its length is interchangeable with the railbound manganese frog.

Moderator Poore: Why offer self-guarded and railbound manganese frogs for Nos. 6 and 8 turnouts and not include bolted frogs? Mr. Zeeman.

Mr. Zeeman: This recommendation is based strictly on economy. While some roads are using bolted rail frogs because of lower first cost or light traffic, it is believed that the types of frogs recommended, while the first cost is greater, will prove more economical on an annual cost basis, due to longer life and lower maintenance cost.

Moderator Poore: Mr. Zeeman, what was the response of the Track committee at the time this proposal was offered for vote?

Mr. Zeeman: I might say that at the last Track committee meeting, the recommendations as submitted, after considerable discussion, were approved unanimously by a verbal vote. However, the response to the letter ballot was a little different. Out of 41 members voting, 34 members approved the recommendations 100 percent, 6 members approved them partially, and one member disapproved them completely.

Moderator Poore: Mr. Bitner, what reduction in cost can be anticipated when these plans are generally adopted and used?

Mr. Bitner: If the recommended turnouts are generally adopted and used by the railroads, the price of the switches and frogs will be reduced about 5 percent by the manufacturers.

In a survey made in 1956, the manufacturers estimated a 3 to 5 percent, or more, reduction in cost if one-half to two-thirds of their turnout production consisted of a single length and design of switch and a single angle and design of frog for yard use, one for main-track slow speed, one for medium speed, and one for high speed.

This report is found on page 959 of the 1957 AREA Proceedings. The AREA Trackwork Plans contain plans for 13 turnouts, 59 frogs and 8 switches, with 36 possible alternates for each switch, depending upon the type of plates, braces, heel blocks, clips, etc., that are used. The presently recommended turnouts will reduce the number of turnouts from 13 to 5, the frogs from 59 to 8, and the switches from 8 to 4, with no alternates for the switches.

Manufacturing costs will surely be lowered by this tremendous reduction in the number of different designs of frogs and switches. In fact, it seems to me that manufacturers might reduce prices of turnout material more than 5 percent if the railroad industry adopts and uses these recommended turnouts.

MODERATOR POORE: Gentlemen, our time is limited but I believe we have enough time for a few questions from the floor. We would like to hear your questions. We'll do our best to answer them.

PRESIDENT WOOLFORD: Speak up, gentlemen. I know you don't all agree. I would argue about the curved switch points. I don't think they are too practical for all railroads. There are other points to argue about, so speak up.

D. L. JERMAN (Pittsburgh & West Virginia): I understand your proposed standardization is based on five turnout designs. Can you justify five turnout designs with approximately 30 rail sections?

MR. ZEEMAN: Unfortunately, we have no jurisdiction to limit the rail sections. We would like to do it, but, naturally, if you have 30 rail sections, as you say—there are only 6 in the Manual that are recommended now—you have 30 times the 5 designs. By that I mean if there is enough difference in the rail base so you have to use a different turnout plan, that is one thing, but if several of the 30 sections have the same rail base and the same width at the head so that you can maintain the same gage and keep the tie plates where they are, you will have a lesser number of turnout plans, but you still have plans for 30 sets of switches in the different lengths. In other words, the 5 turnouts recommended, the 5 standard plans, would cover one rail section, and if you have 6 rail sections, you would have to multiply that by 6.

MR. JERMAN: Do the manufacturers still propose a 10 percent reduction?

MR. BITNER: I didn't say 10 percent. I said 5. Actually, when this question was asked in 1956, thay were asked the percent reduction in cost of frogs, switches and guard rails of existing rail sections, a single length design, etc. So at that time I was talking about existing rail sections.

MODERATOR POORE: Are there any other questions, gentlemen?

J. C. JACOBS (Illinois Central): We have had some difficulty with a 33-ft switch point on a No. 20 turnout in operating through spring switches. That led us to wonder whether it would be practicable at all with a 39-ft switch point, and I wondered whether the committee had given any consideration to this.

MODERATOR POORE: Mr. Klingel, would you volunteer to answer that one?

MR. KLINGEL: I don't know that I can give you much information on that. We were selecting the plans which are now current in the Portfolio. The 39-ft curved switch point is the present recommended switch to go with the No. 20 frog and a No. 20 turnout, and the committee had no information and no knowledge of any trouble with the 39-ft switch points that are being used at the present time.

MR. JACOBS: We have never tried a spring switch with the 39-ft point, but we do have it with the 33-ft point, and there is a good deal of flexibility in the points.

R H. PEAK (Illinois Central): I would like to go to the other end of the spectrum and ask why in choosing your yard turnouts for restricted speed you stopped at a No. 6 and didn't go a step further to the No. 5, which still gives you the curvature that you are interested in.

MODERATOR POORE: Mr. Klingel, I believe you are the one to answer that.

MR. KLINGEL: The sharper the turnout, the more expensive the maintenance and the more difficult the maintenance will be of that turnout. Of these sharp turnouts, the

No. 6 would have very limited application, only where it was absolutely necessary, where it was impossible to use the recommended No. 8 yard turnout. It was the opinion of the committee that the No. 6 turnout would fulfill the requirements for by far the majority of these special locations. There may be—in fact, there probably will be—certain locations some place in the country where some road will require the sharper turnout, the No. 5, or even a No. 4½; but those turnouts could be secured as special trackwork, constructed for that purpose, and the benefits of standardization would not accrue to those special locations. In our opinion, the No. 5 turnout would be a very unusual turnout, for which the demand would be so light that there would be no particular advantage to the standardization.

Moderator Poore: Are there any further questions?

President Woolford: Gentlemen, I might remind you that these curved switch points are not interchangeable. If you adopt curved switch points, you cannot use them interchangeably like you do with your straight points. There are a lot of features in this that ought to be considered very seriously.

B. E. Cors (CB&Q): We have some trouble with PGX cars going through No. 7 turnouts now. How about eliminating that No. 6 completely?

Moderator Poore: Mr. Zeeman, did you hear that question?

Mr. Zeeman: As I understand this gentleman, he wants to eliminate the No. 6 frog as a standard in places where you cannot use the No. 8. Is that correct?

Mr. Cors: We have some trouble getting coupled PGX cars through curves, the air hose coming uncoupled.

Mr. Zeeman: On our road we have used 6½'s, which, of course, are not standard. We haven't had the trouble that you mention. We don't have a crystal ball, so we can't tell what is going to happen in the future. We are trying to do the best we can with the traffic we have to handle now.

Moderator Poore: Are there any further questions?

President Woolford: Speak up, gentlemen. Make your wishes known. I know there are some more of you out there who want to ask questions. Don't be bashful. It looks to me like these recommendations are for a double-track railroad, not a single-track railroad.

Moderator Poore: Gentlemen, if there are no further questions, Mr. Zeeman at this time wishes to resume the presentation and summary of Subcommittee 3.

Mr. Zeeman: Mr. President, now continuing with the report on Assignment 3, the committee believes that, with the published report and the Panel Discussion, you have a clear understanding as to our recommendations. If our basic recommendations for the five standard turnouts meet with general approval, it means that about 20 new plans are required and, of course, the revision of a great number of other plans now in the Portfolio. It is quite obvious that this program involves a lot of work and considerable expense. We believe that the committee could not be expected to go ahead with this program unless there is some expression from the membership that our recommendations are generally satisfactory, as we do not want to waste time and money. If we can get your approval today, we will proceed as quickly as possible, looking to submitting the actual plans for your approval as standard turnouts and recommended practice at the 1961 convention.

In order to obtain your reaction and to stimulate discussion from the floor, we wish to place the matter before you in the form of a motion.

Mr. President, I move to obtain convention approval for the Track committee to proceed with the preparation of the standard plans for turnouts on the basis that the membership is in general accord with the recommendations, now submitted as informa-

tion, listed as items 1 to 15, incl., on pages 938 and 939 of Bulletin 556—this approval to include the Committee's suggestion for placing the standard plans, when adopted, in the front of the Portfolio and placing the other remaining plans of turnout material in the back of the Portfolio, as information.

President Woolford: Gentlemen, this may be a little unorthodox, to ask for a vote on a report that is not finalized, but I do not think that we should go to the expense of preparing all these plans, which are going to be quite a few in number and quite expensive, if when we bring the plans up next year prepared according to the committee's recommendations, we are not going to accept them. That is why Mr. Zeeman has put this motion to you. If it is favorably voted on at this meeting, then this committee and subcommittee will proceed to prepare the detailed plans. This is the kick-off for standardization. Then next year the committee will present the plans for adoption and expect approval. Now, with that thought in mind and that understanding, I will follow through. A motion has been made. Do I hear a second?

Member: Second.

President Woolford: The motion has been made and seconded. Now, are there any questions from the floor, gentlemen, before we act on this? This is a most important item—I would say one of the most important that has come before us this morning. No questions? I think for this one we should have a standing vote. All in favor, please rise. I will let Mr. Howard make the count. OK, will you be seated, please. Now, all that are opposed to the motion, please stand. Come on, gentlemen If you are opposed to it, don't be afraid to express your opinion, OK, there are only 4 standing. Probably 404 stood up the first time. I would say the motion was unanimously passed.

Mr. Zeeman: Your committee also submits, as information, a report prepared by the research staff of the Engineering Division, AAR, which is Appendix 3–a, Service Tests of Designs of Manganese Steel Castings in Crossings at McCook, Ill.

President Woolford: Thank you Mr. Zeeman. It will be so accepted.

Mr. Zeeman: Last, but not least, the committee expresses its appreciation to its associate members, the manufacturers, for their valuable assistance and cooperation in all of our work.

Mr. President, this concludes the report on Assignment 3.

Chairman West: Gentlemen, I certainly do appreciate your approval of this very important subject and your taking a vote. This gives us the green light to go ahead.

I want to thank all the members of Committee 5 for the work they have done this year and to thank the subcommittee chairmen for their support and for the presentations they so ably made.

Mr. President, that completes our report.

President Woolford: Thank you, Mr. West. I am sorry that with the convention time running out, we could not devote more time to presenting the interesting reports of your committee and to the important subject of your panel discussion, although I think we did give the audience sufficient time to express their opinion, which was expressed in the affirmative. I am sure that your presentation here this morning has whetted all of our appetites with respect to these matters and has stimulated our thinking with respect to them. Please keep standardization of track accessories foremost in the minds of all your committee members. Your committee has a lot of work cut out for it in the year ahead, but I am sure it is equal to the task.

Thank you again, Mr. West, and thanks to you, Mr. Poore, and to the members of your panel for your interesting discussion.

Mr. West, your committee is now excused with the thanks of the Association. [Applause]

Closing Business Session

President Woolford: Having completed the formal presentations of all of our technical committees, we are now ready for our closing business session, which will include the installation of our new officers for the coming year. Before beginning that session, however, I want to extend my sincere thanks to everyone who has participated in our program, and also to all those who contributed to the work of our Association during the past year. Through my personal contacts with all of our committees and study of their reports as presented here at this convention, I am satisfied that, by any standard of measurement, our Association has had another most productive year. This can be said only because so many of you have given so generously of your time and effort to that end, and I assure you that your contribution has been appreciated.

There are many others to whom this Association, and especially I as your President, are deeply indebted for their work of the past year and during this convention, and, while it is impossible for me to express adequately our appreciation to each of them at this time, I do want to express my special thanks to our secretary and his staff for their detailed planning of this meeting; and to Chairman Johnson and the members of his committee on Convention Arrangements for the diligence and efficiency with which they have carried out these plans. No one who has not been in a position to see this committee at work, in advance planning, and from early morning until late at night here at our convention, can appreciate the great contribution which its members, individually and collectively, have made to the success of our meeting.

And I want to extend my special thanks to all of those ladies who, with Mrs. Howard, gave so generously of their time to plan and carry out the social functions of our convention for the ladies. Mrs. Woolford joins me in saying to all of them, most sincerely, "We thank you! This, we really mean, as we have enjoyed our close association this year and regret the end is at hand."

While thanking those of our own people for the success of this convention, I am sure you will join me in expressing our appreciation to the management and staff of the Sherman Hotel—and especially Mr. Amico, Mr. Hilbron and Mr. Davis—for a job expertly done on their part and cooperation from their entire staff. They have truly exhibited this year that they can and will meet our specifications, which, along with the fact that the size and facilities of this hotel admirably meet our requirements, is certain to bring us back to the Sherman sometime in the future.

I now call to order the closing business session of this convention. Is there any other business to come before us?

Past President Wm. J. Hedley (Wabash): Mr. President, may I have the privilege of the floor and the podium? I have here a bronze plaque and the inscription on it reads:

"The American Railway Engineering Association records its grateful appreciation to Frank Reardon Woolford for his able administration of the affairs of the Association during his term as President, 1959–60."

Frank, we mean every word of it. The Association has had a fine year of accomplishment under your leadership. You are to be particularly commended for your diligence in attending at least one meeting, and in some instances several meetings, of each of the Association's 23 committees. Your record of traveling more than 200,000 miles during this year establishes you, without question, as the first jet age president of the Association. It is my personal pleasure to present this plaque to you and to welcome you to the ranks of the past presidents of the Association. [Applause]

President Woolford: Thanks, Bill. I will certainly cherish this beautiful plaque and the thought expressed in your conveying it to me. This is surely the "icing on the cake" for me as I complete my year as the pilot of this wonderful Association of railroad engineers, with its most pleasant memories. I hope I have contributed my little to the furtherance of our aims.

The close of our Annual Meeting each year brings with it not only a feeling of satisfaction but always some regrets, because each year, as you know, it brings to an end the services of several members on our Board of Direction. This year, the annual meeting completes the service on the Board of Past President Ray McBrian, director of research, Denver & Rio Grande Western, under the provision of the Constitution that past presidents remain on the Board for only two years following the completion of their term of office as president. I know Ray wishes such provisions were not mandatory, but they are, and we must all step down when the time arrives.

We are all deeply indebted to Mr. McBrian for his long and valuable service to our Association in both an official and unofficial capacity, and in his leaving the Board, we shall miss his sound counsel and advice. But, like our other past presidents, we are not burying him, and I am sure we can continue to call on him for advice on important matters in the future as the occasion may arise. I shall be greatly pleased if Mr. McBrian will stand and be recognized. [Applause]

The terms of office of four of our directors also terminate with the close of this Annual Meeting. These are A. V. Johnston, chief engineer, Canadian National Railways; W. H. Hobbs, chief engineer, Missouri Pacific Railroad; C. J. Henry, chief engineer, Pennsylvania Railroad; and J. C. Jacobs, engineer maintenance of way, Illinois Central Railroad. However, as announced at the Annual Luncheon yesterday, one of these men, Mr. Henry, who has been filling out an unexpired term on the Board, will return to the Board for a full three-year term.

All of these men retiring from the Board have rendered valuable service to our Association, both as working members and in their official capacities on the Board, and, speaking for the members of the Association as a whole, I want them to know that this service has been sincerely appreciated.

I shall recognize Mr. Henry a little later, but if Mr. Johnston, Mr. Hobbs and Mr. Jacobs are present, I would like to recognize them at this time and ask them to stand. [Applause]

It is now my pleasure and privilege to present to you the new directors and officers which you have elected for the ensuing year. As I read the names of the new directors, I shall appreciate their coming to the speaker's table and taking places at my right.

C. J. Henry, chief engineer, Pennsylvania Railroad, Philadelphia, Pa.

J. M. Trissal, vice president and chief engineer, Illinois Central Railroad, Chicago.

W. B. Throckmorton, chief engineer, Chicago, Rock Island & Pacific Railroad, Chicago.

J. A. Bunjer, chief engineer, Union Pacific Railroad, Omaha, Neb.

In your election as directors of this Association, you have been highly honored. Your election is not only recognition of your past interest in and service to this Association, but an expression of the confidence of the membership in each of you to assume leadership in the direction of the Association. I welcome you to the Board of Direction and charge each of you to live up to this confidence and to the responsibilities assumed in your high position. Gentlemen, you may be seated.

Our senior vice president for the year ahead is R. H. Beeder, chief engineer system, Atchison, Topeka & Santa Fe, who, under the Constitution, automatically advances to this position from that of junior vice president. Mr. Beeder, I shall be pleased if you will come to the platform. [Applause]

Your newly elected junior vice president is C. J. Code, assistant chief engineer—staff, Pennsylvania Railroad, who returns to the Board of Direction following a three-year term which ended with our 1958 convention. Mr. Code, I shall appreciate your coming to the platform and standing here with Mr. Beeder. [Applause]

Mr. Code, I think, is known to most of us. He gave a very informative report today in our meeting. Mr. Code was on the Board when I was a director, and I, personally, am very pleased to see him return to the Board as junior vice president.

Mr. Code and Mr. Beeder, I congratulate you on your further elevation to high office in our Association, with the further obligations and opportunities which this affords you for still greater service to the Association. I am sure you will live up to these obligations and opportunities and I wish for both of you the fullest measure of success in your efforts. You may be seated.

As your president for the year ahead, you have elected E. J. Brown, chief engineer, Burlington Lines. To accord Mr. Brown the proper recognition due him, I have asked Past Presidents O'Rourke and Meyers to escort him to the platform, and I would appreciate their doing this at this time.

I am certain you will all be most pleased with Mr. Brown at the helm next year. He has been a most faithful and diligent worker with me in the past year and I know he will carry on in good spirit.

[President elect Brown was escorted to the platform at this point] [Applause]

Mr. Brown, I congratulate you upon your election to the highest position of honor in this Association. I am sure you know I share the confidence which has been placed in you by our membership and, accordingly, it is with pleasure and complete confidence that I turn over the responsibilities of president to you.

In so doing, I want to present you with this solid gold emblem of the Association, which bears the engraved words on the back, "E. J. Brown, President, 1960–1961." [Applause] The best of luck! I am sure you will wear this emblem as a badge of distinction to yourself and to the Association which it represents.

Before we adjourn, I should like to remind you of the Open House at the AAR Research Laboratory this afternoon, beginning at 1:30. Mr. Magee and members of his staff are expecting a goodly number of you and are prepared to show you the facilities at the Laboratory and the tests which are under way there.

Mr. Brown, I will now bow out and turn the podium over to you. [Applause]

President-Elect Brown: Thank you, Mr. Woolford, Members, guests and ladies of the American Railway Engineering Association:

I accept in all humility the honor that has been bestowed upon me by this Association, fully mindful of the responsibilities it entails. When I reflect back on those who have stood here before, as I am today, men of strong character and vision, who directed the advancement of this Association as well as the industry which it represents, it gives me the incentive to give of my all, not only to keep these traditions but to further them if possible.

I think I am singularly honored to have as my helpmates two men like Rudy Beeder and Charley Code. And the Board of Direction, the old members as well as the new, will, I am sure, give me their support.

We have heard the expression that perhaps we are advancing into one of the most critical periods, which is certainly true insofar as our industry is concerned. All of the factors that point toward this trend are well known to this group. So I am motivated by a challenge to further the engineering techniques that will result in making the industry we represent a more efficient and progressive one to meet these conditions.

We are about to close one of our most informative and instructive Annual Meetings, and I have said this all through the meeting: the interest that has been shown, I am sure, is an expression of appreciation of Mr. Woolford's diligent performance of his duties, and of his interest in this Association. I personally want to thank him, because I got a lot out of this Annual Meeting.

President Woolford: Thank you, Mr. Brown.

President-Elect Brown: In connection with committee work, I would strongly urge that every member take a part in it. I say this from experience, because it means so much to the individual as well as to the company that he represents. There is so much to be accomplished by the individual as well as by the Association through this work, and I am looking forward to close contact with these committees.

I do not intend to burden you with a lot of words now, because we have just completed nearly three full days of a very interesting meeting. I would only repeat that I accept the responsibility given me today with the hope that I may receive the help of the full membership. You can be assured that my wife and I will give of our all for a most successful year ahead. Thank you.

H. C. Murphy (CB&Q): Mr. President, I have an assignment I would like to take care of right now.

President-Elect Brown: I am pleased to recognize Mr. Murphy, the president of the Burlington (and a member of the AREA since 1936).

Mr. Murphy: I have here a nice little case and something of interest in it. This is somewhat, I think, like "This Is Your Life," this part of the program. You will recognize first this little device here, which is made to hold the item that I will display later. You will readily recognize it. This is a piece of a crankshaft off a piece of work equipment that you used and took very good care of some 30 years when you were in the Chicago terminal and which we retired only the day before yesterday.

The next item—you probably won't recognize what it is, but it is just to keep you on the beam—is a gavel that you can use to demand attention if there is any interference or any inattention; to keep you properly oriented, it is in the shape of a spike maul. This, too, is an old friend of yours; I presume from the fine grain and the state of preservation, and the identifying marks on the end, which has the year 1930 engraved there, that you will recognize it as a tie you put in on the St. Charles Airline in 1930. Now, the two of them work together like this. I just want to be sure you know how to use them. This is supposed to hold the gavel up so you will have it ready to use instantly.

I think this is a great honor to you, and we on the Burlington are very proud that you have received the honor of heading up an organization like this. I had just a short experience here today in listening to some of the discussions, and I heard Mr. Whitman's very excellent address yesterday. This is an organization that is serious-minded and gives a lot of attention to studying the problems of engineering and maintenance that are so very important to the welfare of the railroads. I know that you will give to these problems and to the duties of your office the same serious consideration, the same care and attention and study, that you have given to the ones that you have fallen heir to on the Burlington over the years.

I have known Mr. Brown for a great many years and I know that he will do everything he can to carry on the fine traditions of this Association. Mr. Brown, I congratulate you and wish you well. [Applause]

President-Elect Brown: Mr. Murphy, I don't know how to thank you for taking time out of your busy schedule to make this presentation to me—I know how busy it is, just try to see him once in a while—so I deeply appreciate this special effort on your part, and the effort of those who participated in the preparation of this fine gavel. I was glad Mr. Murphy made the remark about my taking this tie out 30 years ago. In railroad circles that is usually debatable, it seems. I might say that, knowing where this tie came from, I may have walked over it enough, probably, for it to be worn down to about this size, after carrying on there for nearly 13 years as a roadmaster.

Mr. Woolford reminded you of the open house at the AAR Research Laboratory this afternoon beginning at 1:30. Mr. Magee and the members of his staff are expecting a goodly number and I hope the weather will not deter you, because they have a fine warm place out there and you won't have to be outside too much.

I should like to remind also all members of the Board of Direction, including the retired members and newly elected members, and all members of the Committee on Convention Arrangements, that we have a joint luncheon immediately following the adjournment of this meeting, in the Louis XVI Room. This will be followed by the post-convention meeting of the Board of Direction in the Orchid Room.

Before I make my first use of this beautiful gavel which has been presented to me, may I ask, is there any further business to come before the meeting?

Mr. Murphy: One thing I want to make clear is, lest I failed to do so, that you didn't take that tie out. That tie was taken out yesterday at 1:30. [Laughter]

President-Elect Brown: That clarifies it. I was a little nervous.

If there is no further business to come before the meeting, I now declare the Fifty-ninth Annual Meeting of the American Railway Engineering Association and concurrent Annual Meeting of the Construction and Maintenance Section, Engineering Division, AAR, adjourned.

[The meeting adjourned at 12:30 pm]

MEMOIRS

MEMOIR

Daniel Joseph Brumley

Died December 6, 1959

Daniel Joseph Brumley, a past president and Honorary Member of the American Railway Engineering Association, passed away on December 6, 1959, at the age of 94.

Mr. Brumley was born near Belmore, Ohio, on March 19, 1865. From 1884 to 1890 he taught in rural schools and used his vacations to complete four summer terms at Ohio Northern University. In the fall of 1891, he entered Ohio State University. He was graduated with the degree of Civil Engineer in 1895 and in 1933 received the honorary degree of Doctor of Engineering from the same university.

His 40-year career with the railroad industry began in 1895 with the Louisville and Nashville Railroad, transferring to the Illinois Central in 1904 where he was employed continuously until his retirement at age 70 in 1935. He progressed successively with the Illinois Central from principal assistant engineer through engineer of construction, engineer maintenance of way, assistant chief engineer, valuation engineer, and chief corporate engineer to chief engineer, Chicago Terminal Improvement.

Daniel Joseph Brumley

He joined the American Railway Engineering Association in 1906 and in the subsequent 39 years served on five of its standing committees—1—Roadway and Ballast, 11—Engineering and Valuation Records, 18—Electricity, 25—Waterways and Harbors and 26—Standardization. He was elected a director in 1922, second vice president in 1925, first vice president in 1926, and served as president 1927–1928.

His standing among his railroad associates is well attested by the fact that after his retirement from the Illinois Central in 1935 he was engaged by the Association for an extended period to revise its Manual of Recommended Practice.

In 1947 the Association conferred on him the high distinction of Honorary Member.

Mr. Brumley maintained an active interest in his profession. In addition to his activities in the American Railway Engineering Association he served as president of the Western Society of Engineers and was also a member of the American Railway Guild, American Society of Civil Engineers, American Institute of Electrical Engineers, and Chicago Regional Planning Association. He also served as president of the Ohio State University Association and the Chicago Engineers Club.

Mr. Brumley accepted leadership in civic affairs. He was active in organizing the Village of Flossmoor in 1925 and the Rich Park District in 1933, and served as member of board and president of each. At the time there was no local law enforcement agency, he served as justice of the peace for Rich Township. In 1929 he became a charter member of the Flossmoor Community Church. He also served as member and president of the Flossmoor School District, as chairman of the Cook County Relief Committee in 1933, and for the next two years acted as chairman of the Engineers Division, Illinois Emergency Relief Committee.

Mr. Brumley's main hobby was amateur gardening. He co-authored a book entitled "Preparation and Care of a Vegetable Garden". He developed the "Brumley Tomato", which was accepted by many of his friends as the ultimate in the tomato field and was recognized by a nationally known seed company.

Mr. Brumley's friendly disposition, interest in people, sterling character, fidelity to duty, steadfastness of purpose, and willingness to accept and effectively carry responsibility were recognized and admired by his friends and associates.

Mrs. Brumley preceded him in death on August 31, 1950. He is survived by a son, David Joseph.

C. H. Mottier, *Chairman,*
J. C. Jacobs,
G. M. O'Rourke,
Committee on Memoir.

MEMOIR

William Henry Penfield

Died June 1, 1959

William Henry Penfield, retired chief engineer of the Chicago, Milwaukee, St. Paul & Pacific Railroad, a director of the AREA from 1942 to 1946 and its treasurer from 1937 to 1943, died in the City Hospital at Savanna, Ill., on June 1, 1959. He had been a member of the Association since 1920 and had served on the Committee on Roadway and Ballast, the Committee on Economics of Railway Labor, and the Committee on Standardization, but is best remembered for his service with the Committee on Rail from 1925 to 1949, of which committee he was chairman from 1940 to 1946. He was elected a Member Emeritus of that committee in 1954 in recognition of this service.

Mr. Penfield was born January 12, 1874, at Foxburg, Pa., the son of Edward Walter Penfield and Margaret O'Brien Penfield, and obtained his initial railway experience as a rodman on location surveys on the Buffalo, Rochester & Pittsburgh Railway in January 1894. Thereafter he was advanced in turn to leveler and transitman, and later to resident engineer on the construction of the Pittsburgh extension of that property.

William Henry Penfield

His first service with the Milwaukee Road began on August 1, 1899, being employed as a resident engineer on construction and as a locating engineer until March 1903, when he was afforded an opportunity to broaden his railway engineering experience by taking a position as locating engineer on the Western Pacific Railroad. From then until December 15, 1905, he was engaged in surveys through Beckwith pass in the Sierra Nevada mountains, the upper Feather River Canyon, Deer Creek canyon and the valleys of the Sacramento and San Joaquin rivers.

Leaving the Western Pacific late in 1905, he returned to the Milwaukee, which

had recently announced plans for the extension of its lines to the Pacific coast at Seattle and Tacoma, Wash. On this project he was employed as engineer of construction at Butte, Mont., in charge of both location and construction of the main line from Butte to Lombard, Mont., a distance of nearly 100 miles that includes the crossing of the continental divide at Pipestone pass. Later he became responsible for the location and construction of several branch lines and branch-line extensions.

From June 1911 to February 1913 he was assistant chief engineer, Lines East, and during that time he was in charge of extensive second tracking and grade and line improvements on the main lines between Minneapolis, Minn., and Aberdeen, S. Dak., and across the State of Iowa. He was then assigned to the office of the operating vice-president to serve as an assistant on matters relating to maintenance of way. For some years prior to that time the Milwaukee had no officer with duties corresponding to those of an engineer maintenance of way, and it is no doubt because of his able demonstration of the value of the application of engineering principles to the control of track maintenance that it was subsequently decided to re-establish the position in the person of Mr. Penfield. During the ensuing years the management of the railroad was afforded many demonstrations of the wisdom of that choice.

He proved equal to the task of building up "from scratch" a complete new system organization for the conduct and administration of maintenance of way (later to include also maintenance of structures), and successfully overcame the opposition naturally to be expected in some quarters to such innovations as the interposition of an engineering officer into the division organization between the roadmasters and the superintendent. He was also soon recognized as a maintenance officer who exercised exceptional initiative and imagination in the development of new procedures and practices. Under his leadership the Milwaukee was the first railroad west of Chicago to make extensive use of rails as heavy as 130 lb. The railroad also became one of the pioneers in the organization of system gangs for rail renewals and out-of-face track surfacing, and in the development of gang organizations designed to insure maximum effectiveness in the application of power tools and equipment to track work.

In May 1935 he was advanced to chief engineer, which position he held until his retirement on November 15, 1949.

Mr. Penfield was virtually drafted for the chairmanship of the Committee on Rail as the consequence of the loss by death of the previous chairman and two vice chairmen within the span of seven months. To assume the leadership of this committee without previous intimate contact with the details of its administration called for considerable personal sacrifice on his part. He became responsible not only for orderly procedure on the assigned outline of work from the parent body, but also became the spokesmen for the railroads in their relations with representatives of the rail manufacturers in the conduct of joint research projects having to do with the study of the causes of rail failures. Because of his exceptional qualities of leadership he became an unusually successful chairman.

Mr. Penfield possessed to an exceptional degree those attributes which enabled him to be gracious, affable and unruffled, regardless of the circumstances, and to be just and reasonable in his decisions, while maintaining complete command of the situation at all times in a manner that won him universal respect. He had the knack of bringing forth discussion without participating in it himself to any great extent, and of keeping the discussion going until a well-rounded opinion could be formed and appropriate committee action could be taken. He was patient almost to a fault in the face of prolonged remarks, to the end that no one was denied the opportunity to present his views, while

skillfully avoiding digressions from the subject under discussion. He was a master of diplomacy in dealing with awkward situations, and one of his greatest assets was a ready smile that endeared him to all who enjoyed the privilege of his acquaintance.

His chairmanship of the Committee on Rail embraced the period of America's participation in World War II, when the committee and its chairman was called upon to represent the railroads, through the agency of the Association of American Railroads, in problems growing out of the necessary allotment of scarce materials. As an example of assignments of this nature, which consumed much time and effort, was the appointment of a special committee, of which he was made chairman, to recommend tonnage allotments of rail to the individual railroads out of a total assigned tonnage far below the aggregate of the individual tonnages requested. To this end the committee held a three-day hearing in Chicago at which a representative of each railroad was permitted to present his case.

Mr. Penfield was a good listener and was possessed of a remarkable memory. Nothing that was said at a meeting or conference escaped his notice and he retained what he heard without notes. He always gave a willing ear to the problems of others and was ready to lend his support if he was assured that the cause merited such.

William H. Penfield was married on October 1, 1902, to Grace Kendall Harvey, who died in August 1949. Following his own death and cremation, graveside committal services were held on June 5, 1959, at Oak Hill cemetery near Mount Carroll, Ill., where he and Mrs. Penfield had made their home following his retirement. There being no living relatives, his estate was bequeathed to Frances Shimer College of Mount Carroll.

W. S. Lacher, *Chairman*
T. A. Blair
C. B. Bronson
C. J. Code
G. M. Magee
Ray McBrian
C. H. Mottier
W. G. Powrie
Committee on Memoir

REPORT OF THE EXECUTIVE SECRETARY

March 1, 1960

To the Members:

During 1959 your Association snapped back resiliently from the recession conditions which prevailed in 1958, and, in spite of continued restricted railroad earnings during most of the year due largely to the prolonged steel strike, and a further reduction in railroad employment, closes the year with a favorable record in every important respect—but with a watchful eye to the future. That the record was favorable is due primarily to the inherently sound basis and object of the Association, which are equally as important today as when the Association was organized 60 years ago; to the continued willingness of railway engineering and maintenance officers, through membership and service on committees, to contribute of their time and effort to its work; and to the interest and diligence of its officers and directors to maintain the high professional standards for which the Association has been noted, to encourage membership among the eligible personnel on the railroads, and to adopt measures which have kept the Association financially sound in an era of rising costs of operation. These acts on the part of your officers and directors are set forth in the following review of the various aspects of Association activity during the year, which clearly indicates their favorable impact on the continued well being of the Association.

1959 Convention

The favorable year enjoyed by the Association, particularly in the nature and extent of its work, was, unquestionably, given impetus by the highly interesting and productive annual convention of the Association, March 9–11, at the Sherman Hotel, Chicago, which had a registration of 1132 members and railroad guests and 640 non-railroad guests—a total of 1772, not including the registration of 274 women. This was not a record attendance, being exceeded in several earlier exhibit years, but it compares favorably with the attendance at any of the previous conventions of the Association in non-exhibit years.

The program for the 1959 convention included reports on 146 of the 195 assignments of committees and 13 special features in the form of illustrated papers and addresses, and was noteworthy in a number of respects.

Stimulated by the convention and by a special meeting of all committee chairmen and vice chairmen in April, and by constant encouragement by President Woolford and members of the Board of Direction, committee work continued at a high level throughout the year, taking up some of the recession-induced slack of the previous year. This is reflected in subsequent comments in this report with respect to committee activity and the reports of committees as published in the Association Bulletins, and is certain to be reflected in the character of the 1960 convention.

MEMBERSHIP

Happily, and especially noteworthy, there was an increase in membership during the year, continuing the uninterrupted growth in membership each year since 1944, with the single exception of 1958, which saw a net loss of 52 members. Surprisingly too, for the first time in 7 years there was an increase in the number of Junior Members over the previous year. Both of these facts are particularly significant in the light of the generally unfavorable conditions which prevailed in the railroad industry during the year and the continued tightening within railroad organizations, which saw a further

Committees of the Board of Direction

1959–1960

Executive Committee

F. R. Woolford (chairman), E. J. Brown, B. R. Meyers, R. H. Beeder, J. C. Jacobs

Assignments

A. V. Johnston (chairman), W. W. Hay, W. J. Cruse, C. J. Henry, T. Fred Burris

Personnel

W. H. Hobbs (chairman), C. R. Riley, J. C. Jacobs, F. L. Etchison, W. M. Jaekle

Publications

T. Fred Burris (chairman), W. E. Cornell, W. H. Hobbs, T. M. von Sprecken

Manual

W. W. Hay (chairman), C. J. Henry, Ray McBrian, T. M. von Sprecken, F. L. Etchison

Membership

W. M. Jaekle (chairman), C. R. Riley, W. J. Cruse, A. V. Johnston, W. E. Cornell

Finance

J. C. Jacobs (chairman), B. R. Meyers, R. H. Beeder

Research

E. J. Brown (chairman), C. J. Code, Ray McBrian

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reduction in the total number of technical employees in the engineering and maintenance departments of many railroads and restricted recruitment of technically trained college graduates.

As of February 1, 1960, the membership of the Association stood at 3373, a net gain of 63 over the membership of 3310 one year earlier. This was brought about by the enrollment of 229 new members (compared with 155 in 1958), the reinstatement of 28 former members, and an increase of 15 in Junior Members—an overall gain of 272, which was offset by deaths, resignations and the dropping of members totalling 209. The gain of 15 Junior Members resulted from the addition of 46 new Junior Members (compared with 27 in 1958), a number which was offset by a total of 31 Juniors who either transferred to the grade of Member or who were dropped at the end of the year.

Most of those who joined the Association in 1959—as in past years—did so on their own initiative, but it must be said that the favorable growth in membership during the year, both in members and Juniors, was influenced to a considerable extent by the special effort of the chief engineering and maintenance officers of a few roads, at the instigation of the Board of Direction, to encourage membership among the qualified non-members in their organizations, including the younger technical men who had been taken on in recent years. The most striking example of the effect of this effort is seen in the fact that, as the result of the interest generated by the chief engineer of one

large railroad, 35 qualified men from his railroad submitted applications for membership in the 5 months immediately prior to February 1, 1960. On five other railroads, largely by reason of the same encouragement, the number of applications for membership received in the same period ranged from 10 to 17.

Such interested effort on the part of chief engineering and maintenance officers to increase Association memberships on their roads, plus the equally interested effort on the part of many other engineering and maintenance officers to encourage the retention of membership among their men by adopting an attitude and measures which make the Association of greatest value to these men, are responsible for the present favorable record of membership. And only this personal interest and effort on the part of these same officers can assure the maintenance of this record in the future.

During the year ended February 1, 1960, there were a total of 56 deaths among the membership, as is indicated in the roster of deceased members at the end of this report. This long roster includes one of the two remaining Charter Members of the Association at the beginning of the year, 1 past president, who was also an Honorary Member and a past committee chairman; a past treasurer and director, who was also a past committee chairman; 2 other past directors of the Association, both of whom were past committee chairmen; 3 other committee chairmen, and many others who contributed materially to the work of the Association.

The Charter Member was Wm. Michel, retired chief engineer, Engineering Advisory Committee on Way and Structures, Chesapeake & Ohio, who died on September 13. The past president and Honorary Member was D. J. Brumley, retired chief engineer, Chicago Terminal Improvements, Illinois Central, who died on December 6. Mr. Brumley was president of the Association 1927–1928 and chairman of Committee 25—Waterways and Harbors, 1935. The past treasurer and director was W. H. Penfield, retired chief engineer, Milwaukee Road, who died on June 1. Mr. Penfield was treasurer of the Association 1937–1943, a director, 1944–1946, and chairman of Committee 4—Rail, 1940–1946. The other two past directors of the Association were R. J. Gammie, retired chief engineer, Texas & Pacific, who died on October 19, and J. S. McBride, retired chief engineer, Chicago & Western Indiana, who died on December 9. Mr. Gammie was a director 1951–1953, and chairman of Committee 22—Economics of Railway Labor, 1952–1955. Mr. McBride was a director 1946–1948, and was chairman of Committee 22, 1946–1948. The other three committee chairmen were H. Austill, retired chief engineer, Terminal Railroad Association of St. Louis, chairman, Committee 7—Wood Bridges and Trestles, 1930–1938, who died on October 20; E. M. Grime, retired engineer water service, Great Northern, chairman, Committee 13—Water, Oil and Sanitation Services, 1946–1947, who died on February 7; and B. D. Howe, tie and timber agent, Louisville & Nashville, chairman, Committee 3—Ties, 1949–1952, who died on July 20.

Among the others who died during the year was R. G. May, vice president, Operations and Maintenance Department, AAR (June 2), who, in his capacity with the AAR, worked closely with the officers and directors of the Association, and who had made many significant contributions to the work of the Association, especially through addresses each year to its Annual Conventions.

Even though not noted in the accompanying roster of deceased members, one other death that will prove a great loss to the Association was that of Emil Fritch, clerk in the secretary's office, who died on February 2, 1960. Mr. Fritch has been in the employ of the Association continuously since 1923.

Membership

(February 1, 1959, to February 1, 1960)

Members on the rolls February 1, 1959	3310
New Members	229
Reinstatements	28
Gain in Junior Membership	15
	3582
Deceased	56
Resigned	50
Dropped	103
	209
Net gain	63
Membership February 1, 1960	3373

Membership Classification as of February 1

	1954	*1955*	*1956*	*1957*	*1958*	*1959*	*1960*
Life	401	436	465	470	469	482	481
Member	2366	2381	2414	2478	2524	2491	2527
Associate	270	274	261	258	268	251	264
Junior	220	187	163	144	101	86	101
Totals	3257	3278	3303	3350	3362	3310	3373

ACTIVITIES OF COMMITTEES

Membership on Committees

Reflecting again the personal interest of members in serving on committees, and of the railroads in being represented on committees, is the record of committee membership during 1959. This shows that, in spite of the usual considerable turnover in the rosters of committees for various reasons, more than 1125 members served on committees during the year.

More specifically, as of February 1, 1960, 1128 (including 59 Members Emeritus) were serving in 1247 places on the Association's 23 standing and special committees. This compares with 1125 members who occupied 1246 places on the same committees as of February 1, 1959.

In addition to their regular members, practically all committees carried a number of "guest" members on their rosters—members assigned during the year on a guest basis, but awaiting definite assignment with the official roster change to become effective with the close of the 1960 convention. Also, many committee meetings were attended by "visitors", with the permission of the chairmen. These visitors included retired members, interested outsiders, and members of the Association generally, who, for one reason or another, wished to participate in specific meetings or in inspection trips made in connection therewith.

The turnover of memberships on committees as a whole as of the end of 1959 amounted to approximately 9.6 percent, compared with approximately 10 percent the previous year. This turnover was brought about by the addition of 136 new members on committees and the resignation or dropping of 135 members from committees. The large number of new members involved in this turnover reflects, as indicated earlier, the continuing desire of members and their roads to be represented on committees, while the equally large number of deletions from committee rosters reflects not only the retire-

ment of members from active railroad service and adjustments in personnel on the rail roads, as well as changes in the interests of members, but also implementation of the Board ruling that committee members who cannot or do not participate actively in committee work by attendance, correspondence, and the regular execution of letter ballots, must be dropped from committee rosters. However, that this latter was not an important factor during the past year, in spite of the added regular responsibilities of nearly all members, is seen in the fact that only 21 members were dropped from committees for this cause.

Work of Committees

Working through their subcommittees, the work of committees during 1959 again followed much the same pattern as in previous years, the different subcommittees carrying out their own studies and investigations independently, or working with or through the research staff of the Association of American Railroads, to the end of preparing progress or final reports for information; of revising material appearing in the Association's Manual of Recommended Practice and Portfolio of Trackwork Plans to improve or bring it up to date; of developing new Manual and Portfolio material; and of carrying out special projects related to their assignments. That the work accomplished by committees was substantial is seen in the fact that they produced one or more reports on 120 of their 195 assignments (not including Assignments A), 19 of which were final reports. Furthermore, for the first time, at the request of the Board of Direction, each committee presented brief progress or status statements with respect to all assignments on which it made no formal report.

The interest of committees in keeping their Manual material up to date is reflected in the fact that 17 of the Association's 21 committees which have chapters in the Manual included Manual recommendations in their reports for the year, to be acted upon at the 1960 convention.

Committee Meetings

Sensing some let-up in the special restrictions imposed on committee meetings in 1958, the 23 technical committees of the Association held a few more meetings in 1959 than in the previous year in order to progress their work satisfactorily. However, the large majority of these meetings continued to be held centrally in the country—especially Chicago—or central to the larger number of committee members. Also, many of the meetings were confined to one day. At the same time, a considerable number of the meetings throughout the year were supplemented by inspection trips to see facilities, structures, or practices directly related to the work of committees.

Specifically, 73 full committee meetings were held during the year ended March 1, 1960. This compares with 66 meetings held during the year ended March 1, 1959, 73 meetings held during the year ended March 1, 1958, and 70 meetings during the year ended March 1, 1957. Of the 73 meetings held during the 1959–1960 Association year, 45 were held in Chicago; 2 each were held in Cincinnati, Ohio, Jackson, Miss., Milwaukee, Wis., and New Orleans, La.; 4 were held in Pittsburgh, Pa.; 3 were held in Atlanta, Ga.; and 13 were held in as many different cities, either for special reasons or as most convenient to the majority of members of the committee as a whole. The 45 meetings held in Chicago during the year ,which included 14 meetings and luncheons held during the 1959 convention, compares with 48 meetings held in Chicago the previous year.

Classification of Material Produced by Committees

So diversified was the work of committees during the year that it is impossible to discuss it in other than general terms in a report of this character. But there is presented in the following a general categorical classification of the work produced by the committees, as published in the Bulletins of the Association, and to be presented to the 1960 convention.

Recommendations pertaining to the development, revision, or reapproval without change, of 88 specifications and uniform practices for inclusion in the Manual; 79 reports on current developments in engineering practice and design; 10 reports dealing with economy in the use of labor and the recruiting and training of employees; 6 reports on new and improved power tools, machines, materials and equipment; 2 reports involving statistics; 9 economic and analytical studies; 2 reports on relations with public authorities; and 2 bibliographies.

The work of committees affecting the Manual included the presentation of 3 specifications for adoption; the rewriting or revision of 21 specifications (with or without reapproval); the reapproval of 5 specifications without change; the presentation of 2 tentative specifications; tentative revisions in 5 specifications; the presentation of 6 recommended practices for adoption; the revision of 16 recommended practices, with or without reapproval; the reapproval of 19 recommended practices without change; the presentation of 1 tentative recommended practice; the presentation of tentative revisions in 2 recommended practices; and the presentation of 2 agreement forms for adoption and of a third tentative agreement form. In addition, instructions with regard to five machines were presented for inclusion in the Handbook of Instructions for Care and Operation of Maintenance of Way Equipment.

Work with respect to the Association's Trackwork Plans during the year resulted in the revision of 5 plans, and the presentation of a comprehensive report for consideration by the Association, looking to the development of plans for 5 standard turnouts (3 for main-track, through-train movements, and 2 for yard and switch movements), with auxiliary plans for their component parts, and the resulting necessary revision of many of the plans presently in the Portfolio.

Alert for New Subject Assignments

Beginning early in the year, concurrent with work on their current assignments, all committees gave thoughtful consideration to recommendations for new assignments for 1960. This consideration was again spearheaded within the different committees under their Assignment A. Recommendations for Further Study and Research, by subcommittees, the personnel of which included, in most instances, the vice chairman and all of the subcommittee chairmen of the committee. The result, in all committees, was again the development of far more suggestions for new subjects than could possibly be undertaken, especially in the light of the special instructions to all committees to continue to concentrate during 1960 and 1961 on the review of their material in the Manual, looking to bringing it up to date in advance of the reprinting of the Manual in 1962 to replenish the stock of Manuals on hand for future sales. As a matter of fact, confronted with this heavy Manual review and revision work, some committees took on no new assignments for 1960, and the total number of new assignments given to committees number only 19, which is 17 fewer than the 36 new assignments taken on by committees for 1959.

The overall assignment respecting Manual material during the next 2 years coincides to a large extent with the standing rule that all Manual material must be reviewed and reapproved or up-dated every 10 years, since much of the material presently in the

Manual was last up-dated in 1953, when the entire Manual was overhauled and reprinted in full. Along with this heavy schedule of Manual review and revision during 1960, and work on their 19 new assignments, the committees as a whole will continue work on 170 carried-over assignments, not including their Assignment A—a sizable task indeed.

Close Liaison Maintained Between Board and Committees

In order to keep in close touch with the work of committees, encourage their efforts, and assist where possible, the Board of Direction convened a meeting of all committee chairmen and vice chairmen in Chicago on April 16, as an orientation or refresher session on a wide range of matters affecting committee organization and procedure, and continued several other practices established in recent years to this end.

One of these other practices was that of having an officer or director of the Association sit in, as a guest, on at least one meeting of each committee during the year, with a pre-arranged opportunity for him to present the thinking of the Board on current Association matters and to receive suggestions from the committees.

In this particular practice, President Woolford, even though located at San Francisco, Calif., took a special interest, with the result that, despite the fact that no committee meetings were held west of Colorado Springs, Colo., and the long travel distances involved, he, personally, attended one or more of the meetings of 22 of the Association's 23 standing and special committees—including meetings at points as far east and south as Monteral, Que., Washington, D. C., Atlanta, Ga., and New Orleans, La.

Another of the practices continued by the Board with respect to committees was the careful scrutiny of the activity record of committee members through the Committee Member Activity Charts maintained by all chairmen, which were called in for review by the Board early in October, in connection with the assignment or reassignment of members to committees for 1960.

ASSOCIATION PUBLICATIONS

The calendar year 1959 again continued widespread distribution of the Association's publications beyond its membership, and saw several significant decisions with respect to certain of these publications—even though several of these decisions did not become effective before the beginning of 1960.

Included among the special publication efforts of the Association during the year was the completion of 28,000 copies of the Association's Engineer Recruiting Brochure, approximately one-third of which were sent to the engineering schools of the United States and Canada by the AREA and the School and College Service of the Association of American Railroads; the reprinting of the Student Recruiting Guide developed by Committee 24—Cooperative Relations with Universities, sample copies of which were sent to the chief engineering and maintenance officers of AAR Member Roads; the reprinting of the 1959 report of Committee 24 on "The Role of Engineering Technicians in the Railroad Field", copies of which were sent to the deans or heads of the larger engineering colleges of the United States and Canada, as well as to the chief engineering and maintenance officers of AAR Member Roads; and the authorization of the reprinting, for distribution to the colleges early in 1960, of a long list of railroad technical problems—also developed by Committee 24—as an aid to students seeking problems for Masters or Doctoral research.

Among the special decisions made affecting Association publication was one, still further enhancing of the value of the Committee Assignments pamphlet by the addition

of the personnel of a number of AAR committees or joint committees on which the AREA is represented; a general increase in the prices of most AREA publications to non-members, and of the Manual of Recommended Practice and Portfolio of Trackwork Plans to all purchasers; and the establishment of a flat $1 fee to member-holders of the Manual for Annual Supplements thereto, beginning with the 1960 Supplement—as a means of offsetting the sizable cost to the Association in rendering this special service to that segment of the membership involved.

RESEARCH AND TEST WORK

Research, and both field and laboratory investigation and testing, sponsored by Association committees and carried out by or through the Engineering Division research staff of the AAR, continued at a creditable pace in 1959, but the amount done, both from the standpoint of the number of projects under way and the expenditures made, was far less than had been proposed by committees and hoped for by the Board of Direction. More specifically, whereas AREA committees and the AAR Joint Committee on Relation Between Track and Equipment had proposed to the AAR research and testing work which would have involved an expenditure of $684,000, the AREA Board, recognizing the probable inability of the AAR to finance a program of this size in 1959, submitted a budget calling for a total expenditure of $586,550, divided into two priority groups, and also listed a number of other committee-proposed projects, previously started or new, which the Board stated it would like to see undertaken in 1959 if funds could be made available. The amount of money involved in the additional projects was $54,250.

Late in 1958 the Member Roads of the AAR tentatively approved a 1959 Engineering Division research budget in the amount of $559,550, with the understanding that final approval would await the results of a review of the activities of the Research Department of the AAR and its related budget allotment by a special three-man committee of the AAR Board of Directors. Late in February 1959, following this review, a revised budget was approved authorizing expenditures in the amount of only $353,800.

Basically, the approved budget as a whole reflected the necessity of holding overall expenditures for Engineering Division research in 1959 to a point substantially below those in 1958, and likewise far below those proposed in the research budget request for 1959. It also reflected the opinion of the three-man committee of the AAR Board of Directors which reviewed the proposed budget, to the effect that the research activity and expenditures of the Association in the past had been directed at testing and improving present designs, methods and practices to a degree somewhat more than was desirable, and, furthermore, that more emphasis should be placed upon research to introduce new technologies in railroading.

The size and general scope of the budget having been established, the projects included, modified or excluded from the final budget reflected several things: the removal of projects entirely which were at the bottom of a priority rating established jointly by the AREA Board, the AAR Coordinating Commitee on Physical Research, the director of engineering research, and the vice president, Research Department; a cut in the amount proposed for the remaining projects wherever possible, while still being able to make some headway during the year; and an effort to retain the more experienced members of the Engineering Division research staff, recognizing that to cut off these men would result in a serious loss to the Association in the further progress of its research activities. To accomplish the last-mentioned objective, it was necessary, unfortu-

nately, to eliminate all Research Council participation and other contract work where feasible to do so.

For 1960, Engineering Division research, investigation and testing to be carried out for AREA committees by or through the AAR research staff will again be far less than requested by committees and the AREA Board. Whereas the committee-proposed projects called for a 1960 budget of $749,700, and the AREA Board approved making a budget request of $560,750, the AAR authorized a budget amounting only to $350,300, again reflecting the necessity of holding down expenditures and substantially the same other factors which influenced the restricted Engineering Division research budget in 1959. A summary of the projects included in the authorized budget, showing the expenditures authorized for the different projects, compared with amounts expended for projects in 1959, is presented herewith.

Missing from this authorized budget are a considerable number of projects proposed by committees and most of the items calling for participation in the work of Research Councils. Also, the authorized expenditures for many of the projects included in the budget are considerably below the amounts requested.

Thus, 1960 will be another year of restriction and delay in carrying forward the research, investigation and testing work which had been hoped for by AREA committees and the Board of Direction.

Recognizing that the work done by the AAR research staff for AREA committees falls into two general categories—research, and technical assistance to committees—it is planned to set up the proposed 1961 budget on this basis, differentiating, as clearly as possible, research projects from so-called technical assistance to committee in the form of field and laboratory investigations and testing. Furthermore, to a greater extent than in the past, committees will be requested to accompany their budget proposals with a statement of economic justification for each project.

Total Allotments for Research Work, Engineering Division, AAR, 1943–1960

1943	$ 98,445	1952	381,400
1944	109,050	1953	364,100
1945	138,110	1954	351,307
1946	159,510	1955	351,653
1947	234,428	1956	365,050
1948	291,840	1957	476,845
1949	372,457	1958	563,709
1950	294,045	1959	353,800
1951	354,770	1960	350,300

Summary of Projects Included in 1960 Approved Engineering Division Research Budget Showing Expenditures Authorized for Projects, Compared with Amounts Expended for Projects in 1959

	1959 Expenditure	*1960 Approved Budget*
Administration		
Research Office	$ 51,300	$ 51,300
Total	$ 51,300	$ 51,300

A

	1959 Expenditure	1960 Approved Budget
Committee 1—Roadway and Ballast		
Roadbed Stabilization Study	$ 19,300	$ 19,300
*Vegetation Control by Chemicals	12,800	12,800
Performance of Filter Materials in Subdrains	....	3,000
Total	$ 32,100	$ 35,100
Committee 3—Ties		
Anti-Splitting Devices for Ties	$ 7,000	$ 7,000
Use of Nuclear Energy to Seal and Harden Tie Surface	....	1,000
Total	$ 7,000	$ 8,000
Committee 4—Rail		
Transverse Fissure Investigation	$ 6,350	$ 6,350
Rail Failure Statistics	7,200	7,200
Welding Battered Rail Ends	10,000	10,000
Service Tests of Joint Bars	....	4,300
Tests with 78-ft Rail	4,500	....
Rolling Load Tests of Joint Bars	11,000	....
Insulated Rail Joint Development	....	11,000
Shelly Spots and Head Checks	12,650	12,650
*Standardization of Rail Sections	4,300	4,300
Total	$ 56,000	$ 55,800
Committee 5—Track		
Bolt Tension and Rail Lubrication Tests	$ 4,500	....
*Corrosion Protection of Track and Structures from Brine Drippings (See also Com. 15—Iron and Steel Structures)	6,000	11,400
Manganese Frog Tests-Stresses	9,700	....
Prestressed Concrete Crossing Frog Support	....	6,900
Explosive Hardening of Manganese Frogs	....	2,800
Laying Rail Tight with Frozen Joints	3,500	3,500
Welding Heat Treated Frogs and Switches	4,500	4,500
Specification Development for Tie Plate Fastenings and Tie Pads	15,300	15,300
Total	$ 43,500	$ 44,400
Committee 6—Buildings		
*Wind Load on Buildings	$ 3,000	$ 3,000
Total	$ 3,000	$ 3,000
Committee 7—Wood Bridges and Trestles		
*Timber Stringer Evaluation	$ 6,200	$ 6,200
Fire Retardant Treatment-Standards and Development	8,000	8,000
Preparation of Standard Bridge Plans	2,000	....
Laminated Girders-Design Development	5,200	5,200
*Use of Epoxy Resins on Timber, Masonry and Steel Structures (See also Com. 16—Economics of Railway Location and Operation; Com. 29—Waterproofing	....	5,500
Total	$ 21,400	$ 24,900

* Indicates change in name of project.

	1959 Expenditure	1960 Approved Budget
Committee 8—Masonry		
Concrete Deterioration—Means of Prevention	$ 6,000	$ 6,000
*Bearing Pads for Concrete Bridges	3,000	3,000
Total	$ 9,000	$ 9,000
Committee 9—Highways		
Grade Crossing Study	$ 10,000	$ 10,000
Total	$ 10,000	$ 10,000
Committee 13—Water, Oil and Sanitation Services		
Develop Watering Hydrant to Meet U. S. Public Health Service Requirements	$	$ 2,000
Total	$	$ 2,000
Committee 15—Iron and Steel Structures		
Truss Bridge Research	$ 10,000	$ 10,000
Corrosion of Deck Plates (See Com. 5—Track)	3,000	....
Total	$ 13,000	$ 10,000
Committee 16—Economics of Railway Location and Operation		
Structural Uses of Epoxy Adhesives (See Com. 7—Wood Bridges and Trestles)		
Committee 17—Wood Preservation		
Termite Control Investigation	$ 5,000	$ 1,000
Total	$ 5,000	$ 1,000
Committee 29—Waterproofing		
Bituminous Mastics and Mixes for Waterproofing Structures	$ 12,500	$ 12,500
Epoxy Resin for Waterproofing (See Com. 7—Wood Bridges and Trestles)		
Total	$ 12,500	$ 12,500
Committee 30—Impact and Bridge Stresses		
Impact Studies of Steel Bridges	$ 15,000	$ 14,000
Impact Studies of Concrete Bridges	15,000	14,000
Impact Studies of Timber Bridges	10,000	8,000
*Fatigue of Prestressed Concrete Beams	$ 7,000	$ 7,000
Deflection and Depth Ratio of Bridges	2,000	....
Electronic Calculation of Bridge Stresses	7,000	7,000
Total	$ 56,000	$ 50,000
Joint Committee on Relation Between Track and Equipment		
Relation of Wheel Load to Wheel Diameter	$ 20,000	$ 11,300
Clearance Requirements	10,000	8,000
Wheel Slippage on Axle from Lateral Thrust	3,000	....
Total	$ 33,000	$ 19,300

* Indicates change in name of project.

Board of Committee on Research	*1959 Expenditure*	*1960 Approved Budget*
Long-Range Weather Forecasting	$ 1,000	$ 2,000
Total	$ 1,000	$ 2,000
Electrical Laboratory and Instrumentation	$	$ 12,000
Total	$	$ 12,000
Grand Total	$353,800	$350,300

FINANCES

Despite anticipation of a deficit year for the Association in 1959 an the result of generally rising costs on the one hand, and closely circumscribed income on the other, the Association closed the year with total Receipts exceeding total Disbursements by $109.68—a very desirable and creditable showing. This favorable situation is set forth in the accompaning report of the Treasurer, Financial Statement, General Balance Sheet, and Statement of Cash Receipts and Disbursements for the calendar year 1959, which do show, however, that the total assets of the Association as of the end of the year were some $2000 lower, compared with 1958. A comparison of Receipts and Disbursements for the past two years is presented below:

	1958	*1959*
Receipts	$81,454.56	$80,407.16
Disbursements	77,348.92	80,297.48
	$ 4,105.64	$ 109.68

The following reviews briefly the financial picture for the year. Receipts were lower than those of 1958 by approximately $1000, with sizable increases in some accounts, 1959 over 1958, but with more than offsetting lower Receipts in others.

More specifically, Membership Accounts were some $1000 higher than in 1958, Publications $500, and Research Report Refunds $700. Offsetting the increases in these accounts were lesser amounts received in 1959 for Manual, Advertising, and Convention Registration Fees—$1700, $900, and $700, respectively. These decreases in revenues were not unexpected, as is evidenced by the fact that they were very close to estimated Receipts for these items. Contrarywise, the higher Receipts for the three items referred to above were considerably more than estimated Receipts, and were largely responsible for the Association's Financial Statement showing an excess of $109.68 of Receipts over Disbursements, rather than a loss, as was contemplated at the beginning of the year.

Completing the picture as to why the contemplated excess of Disbursements over Receipts in 1959 did not materialize, is the fact that actual disbursements were very close to the amounts budgeted for most of the various items contained in the 1959 Budget, and the further fact that four items were considerably underexpended as the result of the practice of strictest economy with respect to each item, and reductions in certain contemplated expenditures due either to the fact that these expenditures did not materialize, or to Board-approved economies. The larger underexpended items were: Miscellaneous Stationery and Printing, $1500; Postage, $800; News Letter, $1000; and Recruiting Brochure, $600. The Miscellaneous Stationery and Printing account was under-

expended as the result of fewer publication reprint orders than expected. The Postage account was underexpended because the increased parcel post rates contemplated for 1959 did not become effective until February 1, 1960. The saving in the News Letter account resulted from putting this publication on a bi-monthly basis early in the year. And the $600 saving on the brochure was effected largely by the strictest attention to every element of cost involved in this publication in cooperation with a local printer, rather than, as in the case of the previous edition, having the printing done by a concern inaccessible to the secretary's office.

As the result of all of these factors, the Association, as at the beginning of 1959, ended the year in a sound financial condition—a condition which it is confidently expected will continue to prevail for the foreseeable future with a continuing membership at least at its present level; the holding of expenditures for special, non-remunerative activities and services within practicable limits; the continued exercise of prudence and economy in all necessary expenditures; and a continuation, and extension if necessary, of the policy of making adequate "user charges" for all services afforded non-members and for special services rendered individual members or groups of members.

Comparison of Receipts and Disbursements for a 20-Year Period

	Receipts	*Disbursements*	*Net Gain*
1940	28,272.00	26,451.00	1,821.00
1941	32,433.00	29,384.00	3,049.00
1942	31,500.00	26,692.00	4,808.00
1943	28,736.00	23,809.00	4,927.00
1944	30,492.00	26,534.00	3,958.00
1945	32,305.00	29,305.00	3,000.00
1946	28,836.00	34,583.00	5,747.00*
1947	46,993.00	46,989.00	4.00
1948	57,741.00	53,062.00	4,679.00
1949	62,081.00	57,075.00	5,005.00
1950	59,752.00	51,795.00	7,957.00
1951	69,045.00	62,369.00	6,676.00
1952	77,514.00	76,964.00	550.00
1953	73,033.07	82,067.86	9,034.79*
1954	85,748.99	68,003.03	17,745.96
1955	80,177.21	73,923.18	6,254.03
1956	79,531.11	70,336.17	9,014.94
1957	85,429.31	89,830.57	4,401.26*
1958	81,454.56	77,348.92	4,105.64
1959	80,407.16	80,297.48	109.68

* Deficit.

Stepped-Up Plans for 1960 Convention

As 1959 came to a close, plans were far advanced under the direction of President Woolford for the 1960 convention of the Association, which promises to be one of the most comprehensive and interesting in the long history of AREA conventions—most comprehensive both in the increased number of session hours planned and the extent of the program, and most interesting, on the basis of the largest number of special features in the form of addresses, papers, symposiums, panel discussions and motion pictures, ever included in an AREA convention program. More specifically, nearly three hours are to be added to the available program time by means of an earlier start and later adjournment each day, without increasing the usual two and one-half-day conven-

tion, and, including the Opening Session addresses, the program will contain a total of 24 special features.

With a large attendance, the 1960 convention, as planned, is certain to provide a tremendous initial thrust for launching successfully the work of the 1960–61 Association year.

Respectfully submitted,

NEAL D. HOWARD,
Executive Secretary.

Deceased Members

E. H. ANSON
Vice President, Gibbs & Hill, Inc., New York

S. E. ARMSTRONG
Retired Engineer Maintenance of Way, New York Central System, Cape Porpoise, Me.

H. AUSTILL
Retired Chief Engineer, Terminal Railroad Association of St. Louis, Spring Hill, Ala.

S. R. BAKHSHI
Chicago, Ill.

H. B. BARRY
Retired Chief Engineer, St. Louis-San Francisco Railway, Springfield, Mo.

W. H. B. BEVAN
Retired District Engineer, Canadian National Railways, Willowvale, Ont.

D. J. BRUMLEY
Retired Chief Engineer, Chicago Terminal Improvements, Illinois Central Railroad, Flossmoor, Ill.

D. W. BURNS
Division Engineer, Louisville & Nashville Railroad, Chattanooga, Tenn.

JAMES CAREY
Assistant Division Engineer, New York Central System, Springfield, Ohio

E. E. CHAPMAN
Retired Mechanical Assistant to General Manager, Atchison, Topeka & Santa Fe Railway, Oak Park, Ill.

W. A. CLARK
Retired Office Engineer, Duluth, Missabe & Iron Range Railway, Duluth, Minn.

M. G. COUNTER
District Maintenance Engineer, Chicago, Burlington & Quincy Railroad, Galesburg, Ill.

J. W. DANSEY
Retired Cost Engineer, Atchison, Topeka & Santa Fe Railway, Topeka, Kans.

T. L. DOYLE
Retired Assistant to General Manager, Pennsylvania Railroad, Columbus, Ohio

H. G. Erickson

Chief Engineer, Los Angeles Junction Railway, Los Angeles, Calif.

D. E. Field

Retired Valuation Engineer, Columbus & Greenville Railway, Columbus, Miss.

E. B. Fields

Mechanical Assistant, Engineering and Research, Atchison, Topeka & Santa Fe Railway, Chicago

R. J. Gammie

Retired Chief Engineer, Texas & Pacific Railway, Dallas, Tex.

F. M. Graham

Retired Assistant Engineer of Standards, Pennsylvania Railroad, Sebring, Fla.

R. A. Gravelle

Engineer Maintenance of Way, Grand Trunk Western Railroad, Detroit, Mich.

E. M. Grime

Retired Engineer of Water Service, Northern Pacific Railway, St. Paul, Minn.

W. E. Hawley

Retired Electrical and Signal Engineer, Duluth, Missabe & Iron Range Railway, Duluth, Minn

P. A. Helseth

Consulting Engineer, Minneapolis, Minn.

J. R. Hoagland

Retired Assistant Engineer, Gulf, Mobile & Ohio Railroad, Hemet, Calif.

A. E. Hotard

Assistant Bridge Engineer, Louisville & Nashville Railroad, Louisville, Ky.

B. D. Howe

Tie and Timber Agent, Louisville & Nashville Railroad, Louisville, Ky.

J. R. Kanan

Assistant Engineer of Track, Chicago, Burlington & Quincy Railroad, Galesburg, Ill.

R. G. May

Vice President, Operations & Maintenance Department, Association of American Railroads, Washington, D. C.

J. S. McBride

Retired Chief Engineer, Chicago & Eastern Illinois Railroad, Chicago

F. H. McKenney

Engineer of Track, Chicago, Burlington & Quincy Railroad, Chicago

J. B. McLaren

Retired Comptroller, Canadian National Railways, West Toronto, Ont.

Wm. Michel

Retired Chief Engineer, Engineering Advisory Committee on Way and Structures, Chesapeake & Ohio Railway, Columbus, Ohio

J. M. Miller

Superintendent, Western Maryland Railway, Cumberland, Md.

E. L. Mortimer

General Foreman, Bridges and Buildings, New York, New Haven & Hartford Railroad, Danbury, Conn.

R. F. Patterson

Burlington, Vt.

W. H. Penfield

Retired Chief Engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad, Mt. Carroll, Ill.

A. T. Powell

Retired Assistant Chief Engineer, Grand Trunk Western Railroad, Grosse Pointe Farms, Mich.

C. H. Prater

Supervisor of Track, Illinois Central Railroad, Chicago

T. V. Pyle

Engineer of Design, Elgin, Joliet & Eastern Railway, Joliet, Ill.

L. J. Riegler

Retired Assistant Engineer, Pennsylvania Railroad, Oakmont, Pa.

S. B. Ringgold

Chief Engineer, Mississippi Central Railroad, Hattiesburg, Miss.

W. C. Sadler

Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich.

W. F. Schulz

Consulting Engineer, Memphis, Tenn.

T. C. Shedd

Professor of Structural Engineering Emeritus, University of Illinois, Urbana, Ill.

Lowry Smith

Retired Assistant to Vice President Operation, Northern Pacific Railway, St. Paul. Minn.

W. C. Stewart

Technical Adviser, Industrial Fasteners Institute, Cleveland, Ohio

F. B. Tapley

Retired Engineer Maintenance of Way, Canadian National Railways, Burlington, Ont.

Jamison Vawter

Professor of Civil Engineering, Emeritus, University of Illinois, Urbana, Ill.

R. S. Webster

Division Engineer, United Railways of Havana, Havana, Cuba.

Charles Weiss

Retired Research Analyst, Pennsylvania Railroad, Haverford, Pa.

C. S. Whitney

Partner, Ammann & Whitney, Consulting Engineers, Milwaukee, Wis.

J. L. Willcox

Engineer of Statistics, Atlantic Coast Line Railroad, Wilmington, N. C.

Lef Winship

Retired Abstract Engineer, Missouri Pacific Railroad, St. Louis, Mo.

Edward Wise, Jr.

Engineer Maintenance of Way, Louisville & Nashville Railroad, Louisville, Ky.

A. D. Wolff, Jr.

Retired Assistant Vice President, New York Central System, White Plains, N. Y.

A. H. Woollen

Retired Engineer, Development Division, Aluminum Company of America, Baltimore, Md.

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1959

Balance on Hand January 1, 1959			$149,770.21
RECEIPTS			
Membership Account			
Entrance Fees	$ 2,280.00		
Dues	43,073.70		
		$45,353.70	
Sale of Publications			
Proceedings	1,980.81		
Bulletins	2,304.20		
Manuals	6,985.31		
Specifications	1,950.63		
Track Plans	1,655.35		
Research Reports	6,977.59		
		21,853.89	
Advertising			
Publications		6,035.17	
Interest Account			
Interest on Investments		3,832.68	
Miscellaneous			
Registrations (Convention)	1,945.50		
Luncheon (Ladies)	600.00		
Other	786.22		
		3,331.72	
Total		$80,407.16	
DISBURSEMENTS			
Salaries	$26,082.00		
Proceedings	14,893.99		
Bulletins	14,620.32		
Stationery and Printing	2,985.21		
Rent	1,140.00		
Postage	2,186.46		
Supplies	400.29		
Audit	400.00		
Pensions	300.00		
Social Security and Unemployment Taxes	1,142.10		
Manuals	4,337.05		
Track Plans	568.01		
Committee and Officers expenses	921.85		
Annual Meeting expenses	4,467.25		
News Letter	1,911.38		
Brochure	3,214.41		
Miscellaneous	727.16		
Total		$80,297.48	
Excess of Receipts over Disbursements		109.68	
Balance on Hand December 31, 1959			$149,879.89

REPORT OF THE TREASURER

To the Members:

Balance on hand January 1, 1959		$149,770.21
Receipts during 1959	$ 80,407.16	
Paid out on audited vouchers	80,297.48	
Excess of receipts over disbursements		109.68
Balance on hand December 31, 1959		$149,879.89
Consisting of bonds at cost	148,835.39	
Cash in Northern Trust Company Bank	1,019.50	
Petty cash	25.00	$149,879.89

We have made an examination of the accounts of The American Railway Engineering Association for year ended December 31, 1959, and found them to be in accordance with the foregoing statement.

C. A. Bick,
P. D. Mitchell,
Auditors.

GENERAL BALANCE SHEET

Assets:	*1959*	*1958*
Cash in Northern Trust Company Bank	$ 1,019.50	$ 909.82
Petty cash	25.00	25.00
Due from members	61.00	66.00
Due from sale of publications	26.20	98.50
Due from sale of advertising	1,187.30	956.40
Prepaid postage	3.05	23.81
Furniture and fixtures	1,215.00	1,345.00
Inventories:		
Publications (estimated)	500.00	500.00
Manuals	4,764.00	7,917.00
Track plans	583.00	1,154.50
Binders, index and chapter	46.00	95.00
Paper stock	1,513.60	....
Investments (cost)	148,835.39	148,835.39
Interest accrued on investments	421.06	432.19
Totals	$160,200.10	$162,358.61
Liabilities:		
Members dues paid in advance	$ 374.50	$ 372.00
Surplus	159,825.60	161,986.61
Totals	$160,200.10	$162,358.61

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS YEAR 1959

Cash in Bank, January 1, 1958	$ 909.82
Receipts:	
From members, sales of publications, interest, etc.	80,407.16
Total	$ 81,316.98
Disbursements—Audited vouchers	80,297.48
Cash in Bank, December 31, 1959	$ 1,019.50

American Railway Engineering Association

CONSTITUTION

Revised to October 30, 1958

Article I

Name, Object and Location

1. Name

The name of this Association shall be the AMERICAN RAILWAY ENGINEERING ASSOCIATION.

2. Object

The object of the Association shall be the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways.

3. Means to be Used

The means to be used for this purpose shall be:

(a) The investigation of matters pertaining to the object of the Association through Study and Research Committees.

(b) Meeting for the presentation and discussion of papers, and for action on the recommendations of committees.

(c) The publication of papers, reports and discussions.

4. Conclusions

The conclusions adopted by the Association shall be recommendatory.

5. Location

The office of the Association shall be located in Chicago, Ill.

Article II

Membership

1. Classes

The membership of this Association shall be divided into five classes: Members, Life Members, Honorary Members, Associates and Junior Members.

2. Qualifications

A. General

(a) An applicant to be eligible for membership in any class other than that of Junior Member shall be not less than 25 years of age.

(b) To be eligible for membership in any class, or for retention of membership as a Member, an Associate or a Junior Member, a person shall not be engaged directly or primarily in the sale to the railways of appliances, supplies, patents or patented services.

(c) The right to membership shall not be terminated by retirement from active service.

(d) In determining the eligibility for membership in any class, graduation in engineering from a school of recognized standing shall be considered as equivalent to three years of active practice, and satisfactory completion of each year of work in such school, without graduation, shall be considered as equivalent to one-half year of active practice.

(e) In determining the eligibility for Member under Section B (a) of this Article, each year of practical experience in engineering, or in science related thereto, prior to employment on a railway, if such experience were of the same specialized character as the current work of the applicant, shall be considered as equivalent to one year of railway service.

B. Member

A Member shall be:

(a) An engineer or officer in the service of a railway corporation that is a common carrier, who has had not less than five years' experience in the location, construction, operation or maintenance of railways.

(b) A dean, professor, assistant professor, or equivalent in engineering in a university or college of recognized standing, or an instructor or equivalent in such university or college, who, with an engineering degree, has had at least two years' experience in teaching engineering.

(c) An engineer or member of a public board, commission or other official agency who, in the discharge of his regular duties, deals with railway problems.

(d) An editor of a trade or technical magazine who, in the discharge of his regular duties, deals with railway problems, and who has had the equivalent of five years' engineering or railway experience.

(e) A consulting engineer, engaged in private practice, or an engineer in his employ or in the employ of a consulting engineering organization, who has had the equivalent of five years' engineering experience.

C. Life Member

A Life Member shall be a Member or an Associate who has paid dues for 35 years, or who has been retired under a recognized retirement plan and has paid dues for not less than 25 years.

D. Honorary Member

(a) An Honorary Member shall be a person of acknowledged eminence in railway engineering or management.

(b) The number of Honorary Members shall be limited to ten.

E. Associate

An Associate shall be:

(a) An engineer of a railway which is essentially an adjunct of an industry, or which is used primarily to transport the products and materials of an industry to and from a railway which is a common carrier.

(b) A person qualified by training and experience to cooperate with Members in the object of this Association, but who is not qualified to become a Member.

F. Junior Member

(a) A Junior Member shall be not less than 21 years of age and shall be an engineering employee of a railway corporation who has had not less than three years of experience in the location, construction, operation or maintenance of railways.

(b) His membership in this classification in the Association shall terminate at the end of the calendar year in which he becomes 30 years of age.

(c) He may make application for membership other than as a Junior Member at any time when he becomes eligible to do so.

3. Transfers

The Board of Direction shall transfer from one class of membership to another, or may remove from membership, any person whose qualifications so change as to warrant such action.

4. Rights

(a) Members, and Life Members who were formerly Members, shall have all the rights and privileges of the Association. Life Members who were formerly Associates shall continue to have all the rights and privileges of Associates.

(b) Honorary Members shall have all the rights and privileges of the Association except those of holding elective office, provided, however, that Members or Life Members who are elected Honorary Members shall retain all the rights and privileges of the Association.

(c) Associates and Junior Members shall have all the rights and privileges of the Association except those of voting and holding elective office.

Article III

Admission, Resignation, Expulsion and Reinstatement

1. Charter Membership

The Charter Membership of this Association consists of all persons elected to membership before March 15, 1900.

2. Application for Membership

(a) A person desirous of membership in this Association shall make application upon the form provided by the Board of Direction. In the event that Junior Membership is desired, the applicant shall so state.

(b) The applicant shall give the names of at least three Members of this Association to whom personally known. Each of these Members shall be requested by the Executive Secretary of the Association to certify to a personal knowledge of the applicant with an opinion of the applicant's qualifications for membership.

(c) If an applicant is not personally known to as many as three Members of this Association, the names of well-known persons engaged in railway or allied professional work to whom he is personally known shall be substituted, as necessary, to provide a total of at least three references. Each of these persons shall be requested by the Executive Secretary of the Association to certify to a personal knowledge of the applicant, with an opinion of the applicant's qualifications for membership.

(d) No further action shall be taken upon the application until replies have been received from at least three of the persons named by the applicant as references.

3. Election to Membership

(a) Upon completion of the application in accordance with Section 2 of this Article the Board of Direction through its Membership Committee shall consider the application and make such investigation as it may consider desirable or necessary.

(b) Upon completion of such consideration and investigation, each member of the Board of Direction shall be supplied with the required information, together with the recommendation of the Membership Committee as to the class of membership, if any, to which the applicant is eligible, and the admission of the applicant shall be canvassed by ballot among the members of the Board of Direction.

(c) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (b) of this Article, a two-thirds affirmative vote of the entire Board of Direction shall be required for election.

(d) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (c) of this Article, a unanimous affirmative vote of the entire Board of Direction shall be required for election.

4. Subscription to the Constitution

An applicant for any class of membership in this Association shall declare his willingness to abide by the Constitution of the Association in his application for membership.

5. Honorary Member

A proposal for Honorary Membership shall be endorsed by ten or more Members of the Association and a copy furnished each member of the Board of Direction. The nominee shall be declared an Honorary Member upon receiving a unanimous vote of the entire Board of Direction.

6. Resignation

The Board of Direction shall accept the resignation, tendered in writing, of any person holding membership in the Association whose obligations to the Association have been fulfilled.

7. Expulsion

Charges of misconduct on the part of anyone holding membership in this Association, if in writing and signed by ten or more Members, may be submitted to the Board of Direction for examination and action. If, in the opinion of the Board action is warranted, the person complained of shall be served with a copy of such charges and shall be given an opportunity to answer them to the Board of Direction. After such opportunity has been given, the Board of Direction shall take final action. A two-thirds affirmative vote of the entire Board of Direction shall be required for expulsion.

8. Reinstatement

(a) A person having been a Member, an Associate or a Junior Member of this Association and having resigned such membership while in good standing may be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

(b) A person having been a Member, an Associate or a Junior Member of this Association and having forfeited membership under the provisions of Article IV, Section 3, may, upon such conditions as may be fixed by the Board, be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

Article IV

Dues

1. Entrance Fee

(a) An entrance fee of $10 shall be payable to the Association with each application for membership other than Junior Membership. This sum shall be returned to an applicant not elected.

(b) No entrance fee shall be required for Junior Membership, except that a Junior Member, in transferring to another class of membership, shall pay the entrance fee prescribed for other classes of Membership.

2. Annual Dues

(a) The annual dues for each Member and each Associate shall be $15.

(b) The annual dues for each Junior Member shall be $5.

(c) Life Members and Honorary Members shall be exempt from the payment of dues. Life Members desiring to continue to receive the Bulletins and Proceedings of the Association may do so by paying a subscription fee prescribed by the Board of Direction.

3. Arrears

A person whose dues are not paid before April 1 of the current year shall be notified by the Executive Secretary. If the dues are still unpaid on July 1, further notice shall be given, informing the person that he is not in good standing in the Association. If the dues remain unpaid by October 1, the person shall be notified that he will no longer receive the publications of the Association. If the dues are not paid by December 31, the person shall forfeit membership without further action or notice, except as provided for in Section 4 of this Article.

4. Remission of Dues

The Board of Direction may extend the time of payment of dues, and may remit the dues of any Member, Associate or Junior Member who, for good reason, is unable to pay them.

Article V

Officers

1. Officers

(a) The officers of the Association shall be a President, two Vice Presidents, twelve Directors, an Executive Secretary and a Treasurer.

(b) The President, the Vice Presidents and the Directors, together with the two latest living Past Presidents continuing to be Members, shall constitute the Board of Direction, in which the government of the Association shall be vested; they shall act as the trustees and have the custody of all property belonging to the Association. The President, the Vice Presidents and the Directors shall be Members.

(c) The Executive Secretary and the Treasurer shall be appointed by the Board of Direction.

2. Term of Office

The term of office of the President shall be one year, of the Vice Presidents two years and of the Directors three years. The term of each shall begin at the close of the annual convention at which elected and continue until a successor is qualified. All other officers and employees shall hold office or position at the pleasure of the Board of Direction.

3. Officers Elected Annually

(a) There shall be elected at each annual convention a President, one Vice President and four Directors.

(b) The candidates for President and for Vice President shall be selected from the members or past members of the Board of Direction.

4. Conditions of Re-election of Officers

A President shall be ineligible for re-election, except as provided for in Section 5 (e) of this Article. Vice Presidents and Directors shall be ineligible for re-election to the same office, except as provided for in Section 5 (e) of this Article, until, at least one full term has elapsed after the end of their respective terms.

5. Vacancies in Offices

(a) If a vacancy should occur in the office of President, as set forth in Section 6 of this Article, the senior Vice President shall immediately and automatically become President for the unexpired term.

(b) If a vacancy should occur in the office of the senior Vice President, due to advancement under Section 5 (a) of this Article, or for reasons set forth in Section 6 of this Article, the junior Vice President shall automatically become senior Vice President for the unexpired term.

(c) If a vacancy should occur in the office of the junior Vice President, due to advancement under Section 5 (b) of this Article, or for reasons set forth in Section 6 of this Article, the Board of Direction shall by the affirmative vote of two-thirds of its entire membership, select a junior Vice President from the members or past members of the Board of Direction.

(d) A vacancy in the office of Director, due to advancement of a Director to junior Vice President under Section 5 (c) of this Article, or for reasons set forth in Section 6 of this Article, shall be filled by the Board of Direction by the affirmative vote of two-thirds of its entire membership.

(e) An incumbent in any office for an unexpired term shall be eligible for re-election to the office held; provided, however, that anyone selected to fill a vacancy as Director shall be eligible for election to that office, excepting that such appointee filling out an unexpired term of two years or more shall be considered as coming within the provisions of Section 4 of this Article.

6. Vacation of Office

(a) In the event of the death of an elected officer, or his resignation from office, or if he should cease to be a Member of the Association as provided in Section 2 (B), Article II; Section 6 or 7, Article III; or Section 3, Article IV, the office shall be considered as vacated.

(b) In the event of the disability of an officer or neglect in the performance of duty by an officer, the Board of Direction, by the affirmative vote of two-thirds of its entire membership shall have the power to declare the office vacant.

Article VI

Nomination and Election of Officers

1. Nominating Committee

(a) There shall be a Nominating Committee composed of the five latest living Past Presidents of the Association, who are Members, and five Members who are not officers.

(b) The five Members who are not Past Presidents shall be elected annually for a term of one year, when the officers of the Association are elected.

(c) The senior Past President who is a member of the committee shall be the chairman of the committee. In the absence of the senior Past President from a meeting of the committee the Past President next in seniority present shall act as chairman.

2. Method of Nominating

(a) Prior to December 1 of each year the chairman shall call a meeting of the committee at a convenient place, at which nominees for the several elective offices shall be selected as follows:

Office to be Filled	*Number of Candidates to be named by the Nominating Committee*	*Number of Candidates to be elected at the Annual Election of Officers*
President	1	1
Vice President	1	1
Directors	8	4
Nominating Committee	10	5

(b) The chairman of the Nominating Committee shall send the names of the nominees to the President and Executive Secretary not later than December 15 of the same year, and the Executive Secretary shall report the names of these nominees to the members of the Association not later than January 1 following.

(c) At any time between January 1 and February 1 any ten or more Members may send to the Executive Secretary additional nominations for any elective office for the ensuing year signed by such Members.

(d) If any person nominated shall be found by the Board of Direction to be ineligible for the office for which nominated, or should a nominee decline such nomination, his name shall be withdrawn. The Board of Direction may fill any vacancies that may occur in the list of nominees up to the time the ballots are sent out.

3. Ballots Issued

Not less than thirty days prior to each annual convention, the Executive Secretary shall issue a ballot to each voting Member of record who has paid his dues to or beyond December 31 of the previous year, listing the several candidates to be voted upon. When there is more than one candidate for any office, the names shall be arranged on the ballot in the order that shall be determined by lot by the Nominating Committee. The ballot shall be accompanied by a statement giving for each candidate his record of membership and activities in this Association.

4. Substitution of Names

Members may remove names from the printed ballot list and may substitute the name or names of any other person or persons eligible for any office, but the number of names voted for each office on the ballot must not exceed the number to be elected at that time to such office.

5. Ballots

(a) Ballots shall be placed in an envelope, sealed and endorsed with the name of the voter, and mailed to or deposited with the Executive Secretary at any time previous to the closure of the polls.

(b) A voter may withdraw his ballot, and cast another, at any time before the polls close.

(c) Ballots received in unendorsed envelopes, or from persons not qualified to vote, shall not be counted.

(d) The ballots and envelopes shall be preserved for not less than ten days after the vote is canvassed.

6. Closure of Polls

The polls shall be closed at 12 o'clock noon on the second day of the annual convention, and the ballots shall be counted by tellers appointed by the presiding officer.

7. Election

(a) The persons who shall receive the highest number of votes for the offices for which they are candidates shall be declared elected.

(b) In case of a tie between two or more candidates for the same office, the Members present at the annual convention shall elect the officer by ballot from the candidates so tied.

(c) The presiding officer shall announce at the convention the names of the officers elected in accordance with this Article.

Article VII

Management

1. President

The President shall have general supervision of the affairs of the Association, shall preside at meetings of the Association and of the Board of Direction, and, by virtue of his office, shall be a member of all committees, except the Nominating Committee.

2. Vice Presidents

The Vice Presidents, in order of seniority, shall preside at meetings in the absence of the President.

3. Treasurer

The Treasurer shall pay all bills of the Association when properly certified by the Executive Secretary and approved by the Finance Committee. He shall make an annual report as to the financial condition of the Association and such other reports as may be called for by the Board of Direction.

4. Executive Secretary

The Executive Secretary, under the direction of the President and Board of Direction shall be the Executive Officer of the Association and shall attend the meetings of the Association and of the Board of Direction, prepare the business therefor, and record the proceedings thereof. The Executive Secretary shall see that all money due the Association is collected, is credited to the proper accounts, and is deposited in the designated depository of the Association, with receipt to the Treasurer therefor. He shall personally certify to the accuracy of all bills and vouchers on which money is to be paid. He shall invest all funds of the Association not needed for current disbursements, as shall be recommended by the Finance Committee and approved by the Board of Direction, with notification to the Treasurer of such investments. The Executive Secretary shall conduct the correspondence of the Association, make an annual report to the Association, and perform such other duties as the Board of Direction may prescribe.

5. Auditing of Accounts

The financial accounts of the Association shall be audited annually by an accountant or accountants approved by and under the direction of the Finance Committee.

6. Board of Direction and Executive Committee

(a) The Board of Direction shall manage the affairs of the Association, and shall have full power to control and regulate all matters not otherwise provided for in the Constitution.

(b) The Board of Direction shall meet within thirty days after each annual convention, and at such other times as the President may direct. Special meetings shall be called on request, in writing, of five members of the Board of Direction.

(c) Seven members of the Board of Direction shall constitute a quorum.

(d) At the first meeting of the Board of Direction after the annual convention, the President shall appoint from the membership of the Board, subject to ratification by the Board, four members to serve with him as an Executive Committee which shall possess and may exercise during intervals between meetings of the Board, all of the powers of the Board on matters which in the judgment of a majority of the Executive Committee cannot properly be delayed until the next meeting of the Board. Actions of the Executive Committee shall be reported to the Board of Direction at the next meeting of the Board. The President shall be chairman of the Executive Committee. Actions of the Executive Committee shall be authorized by a concurring majority of its full membership. Members of the Executive Committee shall serve until their successors are appointed or until the Executive Committee is dissolved by action of a majority of the full membership of the Board of Direction. Following dissolution of the Executive Committee it may be re-created at any time by action of a majority of the full membership of the Board of Direction. If not so re-created prior to the next annual convention, the Executive Committee shall be reconstituted in the normal manner at the first meeting of the Board of Direction following the convention.

7. Administrative Committees

At the first meeting of the Board of Direction after the annual convention, the following Administrative Committees, each consisting of not less than three members, shall be appointed by the President. The personnel of these committees shall be subject to approval by the Board of Direction.

Assignments
Finance
Manual
Membership
Personnel
Publications
Research

Other special Administrative Committees may be appointed by the President at any time, and reappointed annually, if necessary, their personnel being subject to approval by the Board of Direction.

Membership on Administrative Committees shall be restricted to members of the Board of Direction, except that one or two members of the Administrative Committee on Research may be past members of the Board of Direction.

8. Study and Research Committees

The Board of Direction may establish continuing or special Study and Research Committees to investigate, consider, and report upon subjects appropriate to the object of the Association, as set forth in Art. I.

9. Duties of Administrative Committees

(a) Assignments

The Assignments Committee shall review and pass upon the recommendations of Association Study and Research Committees for subjects to be investigated, considered and reported on by these committees during the ensuing Association year, and shall

report thereon to the Board of Direction for its approval. The Assignments Committee shall have authority to assign additional subjects or change the scope of any existing subjects at any time during the year, reporting its action thereon to the Board at its next regular meeting.

(b) Finance

The Finance Committee shall have immediate supervision of the accounts and financial affairs of the Association; shall approve all bills before payment, and shall make recommendations to the Board of Direction as to the investment of funds and other financial matters. The Finance Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money other than the amounts necessary to meet ordinary current expenses of the Association, except by authority of the Board of Direction.

(c) Manual

The Manual Committee, with the assistance of the Publications Committee, shall have general supervision over the Manual.

(d) Membership

The Membership Committee shall investigate applicants for membership and shall make recommendations to the Board of Direction with reference thereto.

(e) Personnel

The Personnel Committee shall review and pass upon applications of members for appointment to Study and Research Committees, and shall also appoint the chairman and vice chairman of such committees and make a report thereon to the Board of Direction for its approval. Should an unexpected vacancy in chairmanship or vice chairmanship of any such committee occur, the Personnel Committee shall have authority to fill such vacancy immediately, reporting its action thereon to the Board at its next regular meeting.

(f) Publications

The Publications Committee shall have general supervision over the publications of the Association. The Publications Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money except by authority of the Board of Direction.

(g) Research

The Research Committee shall encourage and coordinate the research activities of the Association, in the course of accomplishment of which it shall review and pass upon the recommendations of Study and Research Committees for research projects and shall report thereon to the Board of Direction, recommending for approval specific projects initiated by these committees or by the Research Committee and recommending allotments of funds for these projects in the research budget of the Association of American Railroads or from other sources compatible therewith; shall collaborate closely with the research staff of the Association of American Railroads; and when called upon by the Vice President—Research or the Vice President—Operations and Maintenance of that association, members of the Research Committee shall engage in the activities of advisory committees or groups of that organization and shall report from time to time to the Board of Direction on those activities.

10. Special Committees

The Board of Direction may appoint special committees to examine into and report upon any subject connected with the objects of this Association.

11. Discussion by Non-Members

The Board of Direction may invite discussions of reports from persons not members of the Association.

12. Sanction of Act of Board of Direction

An act of the Board of Direction which shall have received the expressed or implied sanction of the membership at the next annual convention of the Association shall be deemed to be the act of the Association.

Article VIII

Meetings

1. Annual Convention

(a) The Annual Convention of the Association shall be held in the City of Chicago, Ill., or in such other city as may be determined by the affirmative vote of two-thirds of the entire membership of the Board of Direction. The convention shall open on the second Tuesday in the month of March, or on the third Tuesday if the month of March has five Tuesdays, excepting that some other opening day in March may be designated by the affirmative vote of two-thirds of the entire membership of the Board of Direction

(b) The Executive Secretary shall notify all members of the Association of the time and place of the annual convention at least 30 days in advance thereof.

(c) The order of business at the annual convention of the Association shall be:

Reading of the minutes of the last meeting
Address of the President
Reports of the Executive Secretary and the Treasurer
Reports of committees
Unfinished business
New business
Installation of officers
Adjournment

(d) This order of business may be changed by a majority vote of Members present.

(e) The proceedings shall be governed by "Robert's Rules of Order" except as otherwise herein provided.

(f) Discussions shall be limited to Members and to those others invited by the presiding officer to speak.

2. Special Meetings

Special meetings of the Associations may be called by the Board of Directions on its own initiative, and may be so called by the Board of Direction upon written request of 100 Members. The request shall state the purpose of such meeting.

The call for such special meeting shall be issued not less than ten days in advance of the proposed date of such meeting and shall state the purpose and place of the meeting. No other business shall be taken up at such meeting.

3. Quorum

Twenty-five Members shall constitute a quorum at all meetings of the Association.

Article IX

Amendment

1. Amendment

Proposed amendment of this Constitution shall be made in writing, shall be signed by not less than ten Members, and shall be acted upon in the following manner:

The amendment shall be presented to the Executive Secretary, who shall send a copy to each member of the Board of Direction as soon as received. If a majority of the entire Board of Direction so votes, the matter shall be submitted to the Association by letter ballot.

Sixty days after the date of issue of the letter ballot, the Board of Direction shall canvass the ballots which have been received, and if two-thirds of such ballots are in the affirmative the amendment shall be declared adopted and shall become effective immediately. The result of the letter ballot shall be announced to members of the Association.

Information and Rules for the Guidance of Committees

The following information and rules for the guidance of committees are designed to obtain the maximum benefits from the efforts of the members who make up the personnel of such committees. They are designed to effect a continuity of effort in committee work throughout the entire year, under a plan whereby the personnel of the committees and their respective assignments for investigation and report are set up and made public on or before the beginning of the calendar year, thus enabling the work to be continued without interruption, although the new personnel and subject assignments do not become officially effective until the beginning of the "Association Year," which starts with the close of the annual meeting.

The rules also take into account the fact that the publication of the committee reports must be spread out over a period of four months (November through February), to facilitate printing and to give members of the Association a reasonable length of time in which to study such reports in advance of the annual meeting.

SUBJECT ASSIGNMENTS

Reassigned Annually

The assignments for investigation and report of each committee shall be reviewed annually. To this end, each committee shall review suggestions for new subjects submitted by its Subcommittee A, by other members of the committee, or by others, and such suggestions as receive the approval of the committee shall be submitted by the committee chairman to the executive secretary of the Association not later than October 1. Each suggestion shall be accompanied by brief explanation of the purpose and scope of each proposed assignment, or change in the wording of present assignments. At the same time, the committee chairman shall submit the committee's recommendations covering the withdrawal or continuation of current assignments, with a brief statement of the reason or reasons therefor.

The recommendations received from the various committees shall be assembled and forwarded to the Board Committee on Assignments, which has the responsibility of authorizing the subject assignments to the various committees. Deviations from assignments thus authorized may be made during the course of the year only upon authority of the Board Committee on Assignments. However, this is not to be construed as preventing any committee from proposing additional urgent assignments at any time during the year, upon which it feels work should be begun promptly.

Scope of Assignments of Committees 22 and 27

The scope of assignments of Committee 22 will encompass studies relating to the economics of various types of work equipment as used by the labor forces to which they are assigned, including the labor savings that may be effected, production, and quality of work.

The scope of assignments of Committee 27 will encompass studies involving the mechanical features, operating characteristics, development and maintenance of work equipment, and fuels, lubricants, etc., necessary for its operation; also pertaining to such labor aspects as the selection and training of equipment operators, maintainers and repair forces.

Either or both committees may include in their considerations and reports factors of design or operation that affect productivity or quality of work, and such economic aspects as first cost, obsolescence, life, depreciation, and maintenance and repair costs as may be necessary to the comprehensive development of their respective assignments.

In the case of an overlapping assignment, the assignment should normally be handled by the committee principally affected in the light of the foregoing paragraphs, with the other committee collaborating.

COMMITTEE PERSONNEL

Reorganized Annually

The personnel of each committee shall be reorganized annually. It is desirable that 10 percent of the membership be changed each year. Members who do not attend meetings of the committee, who do not render service by correspondence, or who do not return letter ballots will be dropped. To this end the chairman of the committee shall submit to the secretary's office not later than October 1 the current Committee Member Activity Record Chart, filled out in full regarding each member, and showing in the appropriate columns which members he recommends be dropped because of delinquency in service to the committee, or for other reasons, and those members he recommends be continued on the committee. The chart, at the bottom, should also list any members he recommends for appointment to the committee, whether previously carried as "guest" members or not.

The recommendations received from the various committees shall be assembled and forwarded to the Board Committee on Personnel, which has the duty of appointing the committee personnel.

No additions to the personnel of committees will be made during the year following the official closing of committee rosters, October 1, except as provided for in the rules applying to "Guests."

Members who desire appointment to a committee should make application through the committee chairman or the executive secretary on the prescribed form.

Chairmen, Vice Chairmen and Subcommittee Chairmen

Chairmen, vice chairmen and subcommittee chairmen must hold the grade of Member in the Association, and be in active service of their respective companies or organizations (not retired).

The term of chairman and vice chairman shall be three years in each position, and will normally start at the beginning of the Association year, at the close of an annual meeting. However, the term of office of vice chairman will be shorter if he is appointed to fill a vacancy in the position of vice chairman. Chairmen completing their three-year term shall recommend to the Board Committee on Personnel nominees for the chairmanship and vice chairmanship, with assurance of acceptances from such nominees if appointed by the Board Committee. The term of office of subcommittee chairman may be more than three years.

In the event of a vacancy in the office of chairman, the office shall be filled by the vice chairman, subject to the approval of the Board Committee on Personnel. The three-year term of office of the chairman so approved, or of a new appointee shall be considered as having started as of the end of the immediately preceding convention if the appointment is made prior to the time the committee's report is due in the secretary's office, and as becoming effective as of the end of the next convention if the appointment is made after the committee's report is due in the secretary's office.

In the event of a vacancy in the office of vice chairman, it shall be the duty of the Board Committee on Personnel to fill the vacancy. The term of office of the vice chairman so appointed shall be considered as having started as of the end of the immediately preceding convention if the appointment is made prior to the time the committee's report is due in the secretary's office, and as becoming effective as of the end of the next convention if the appointment is made after the committee's report is due in the secretary's office.

Committee Secretary

Any chairman may appoint a secretary with duties usually encompassed by such office.

Size of Committees*

The total membership of any committee shall be limited to 70, including Members, Associates, and Junior Members, but not counting retired members, even though gainfully employed.

In determining the membership of a committee, railroads having no more than 50 Association members may have not more than 2 members on any committee; railroads having 51 to 100 members may have not more than 3 members on any committee; railroads having more than 100 members may have not more than 4 members on any committee.

No college, university or other institution of learning shall have more than 2 members on any committee, and no manufacturer or supply company or other organization shall have more than 1 Member or Associate member on any committee.

Retired Members

Members who have retired from active service under normal retirement procedure, regardless of whether they undertake other employment (other than sales to the railroads), may serve on committees and subcommittees a maximum of three years following retirement, but cannot hold the office of chairman, vice chairman, or subcommittee chairman, and have no voting rights on technical matters. Their presence on the committee roster shall not be counted in the application of the rules affecting the total number of members permitted on committees, the number of associates permitted on a committee, or the rules having bearing upon the number of members on committee permitted from any railroad, supply company, or other organization. Following termination of their service on committees, retired members may continue to attend committee meetings as "visitors" subject to the approval of the committee chairman involved.

Associate Members*

No company will be permitted to have more than one Associate member on any committee, and company representation shall not necessarily be continuing. However, in the event that a railroad member on a committee becomes associated with a manufacturer or supply company (in other than a sales capacity) after retirement from railroad service on pension, and thus automatically becomes an Associate member, he shall not be deprived of membership on the committee during the period of three years,

* In applying any of the rules under the headings: Size of Committees and Associate Members, see paragraph under heading "Retired Members," and third last paragraph under heading "Member Emeritus."

following his retirement from railroad service. As regards the voting rights of Associate Members on committees, see "Voting in Committees."

The membership of Associates on a committee shall be limited to 10 percent of the total membership of the committee. Committees with Associates in excess of 10 percent of their total membership are not required to reduce the number of Associates immediately for the purpose of complying with this rule, but no Associates may be added as long as the proportion of Associates exceeds 10 percent, except as may be occasioned by the exception provided in the preceding paragraph or the exceptions set forth under "Retired Members" and "Member Emeritus."

Member Emeritus

This class of committee membership was established in 1953 in order to permit recognition of long-sustained meritorious service of committee members to committees, following their retirement.

To be eligible for this honor, or to retain this honor, a member must be in good standing in the Association as a Member, Honorary Member, Associate, or Life Member, and must have:

(a) Retired under normal retirement procedure from active service in the company with which he has been connected.

(b) Served on the committee at least 10 years. (Executive secretary's office can furnish service record on any retired committee member.)

(c) Rendered outstanding service to the committee over a period of years.

(d) Been proposed by at least five committee members in writing and voted the honor by a two-thirds affirmative letter ballot of all members of the committee, including Associates, retired members and Junior Members—the letter ballots to be returnable to the executive secretary's office within 60 days. (Secretary's office can furnish sample type letter ballot).

The number of such members permitted on any committee will be limited to five.

Furthermore, his election as Member Emeritus must be affirmed by the Board Committee on Personnel through the executive secretary's office.

Having been elected as Member Emeritus, the member's name will continue to appear on the roster of the committee, and he will have all rights and privileges of committee members except that of voting on technical matters (i.e., can serve on subcommittees, should he desire, in order that the committee might benefit from his knowledge and experience). Likewise, his name will continue to be shown in the printed roster of the committee appearing in the Bulletins of the Association, and in the Assignments Pamphlets, in each case suitably designated as Member Emeritus. However, the names of Members Emeritus will not be designated by an "E" or otherwise in the alphabetical listing, railroad listing, Honorary Member listing, or Life Member listing in the March Bulletin.

Members Emeritus will not be counted in the application of the rules affecting the total number of members permitted on committees, the number of associates permitted on a committee, the rules having bearing upon the number of members on committees permitted from any railroad, supply company, or other organization, or the number of years that a retired member may serve on a committee. Any Emeritus title will terminate with the death of the recipient, or in the event of the termination of his membership in the Association for other reasons.

Nothing in these rules will prevent extending the honor of Member Emeritus to a retired committee member who may have taken up, or who subsequently takes up, other employment following his official retirement.

Tangible evidence of this honor will be given to those so named in the form of a pocket card, similar in form to a railroad pass, signed and sent out by the committee chairmen.

"Guests" and "Visitors"

The previously stated rule under Committee Personnel Reorganized Annually, that "no additions to the personnel of committees will be made during the year following the official closing of committee rosters, October 1, except as provided for under the rules applying to Guests," does not preclude the attendance at committee meetings of other members of the Association, and non-members of the Association, as "Visitors," with the approval of committee chairmen.

If there are vacancies on a committee roster after the official closing of committee rosters on October 1, (i.e., less than 70), or if vacancies occur during the following year, or are definitely in prospect at the end of that year, Association members (including Junior members), with the approval of committee chairmen and the Board Committee on Personnel, can be appointed as "guests" of that committee. As such, they may attend committee meetings and participate in the committee's activities, unofficially, looking to becoming regularly assigned members at the beginning of the next Association year (March).

"Guests" must always be designated as such on the rosters maintained by the committees and the secretary's office, but their names will not appear in published committee or subcommittee reports. Creation of this class of committee affiliation is not intended to increase the size of any committee beyond the 70 maximum set by the Board, but rather to make it possible to add to "short" rosters between official roster changes.

Furthermore, one need not be either a "regular member" or a "guest" of a committee to attend its meetings from time to time. With the approval of the committee chairman, who must be consulted as regards any specific meeting, any AREA member (including Junior Members), or any non-member may sit in on the meeting as a "visitor", listen to all deliberations and participate in discussions.

Service on More Than One Committee

No member of the Association shall serve on more than one committee, except that a member may serve on two committees if one or both of the committees are among the following: Committee 3—Ties; Committee 7—Wood Bridges and Trestles; Committee 17—Wood Preservation; Committee 20—Contract Forms; Committee 24—Cooperative Relations with Universities; Committee 25—Waterways and Harbors; Committee 28—Clearances; Committee 29—Waterproofing; Committee 30—Impact and Bridge Stresses; and the Special Committee on Continuous Welded Rail.

COMMITTEE ORGANIZATION AND PROCEDURE

Organizing the Committees

The new assignments and personnel of committees shall become effective with the close of the annual meeting in March. However, the pamphlet containing this information is issued not later than January 1 in order that committees may be reorganized immediately after January 1 for the new year's work, if reorganization has not already

been effected. Usually this information will be available to the chairmen in tentative form at least 30 days in advance of publication.

It is the duty of the committee chairman to notify new members promptly of their appointment and to notify old members of their reappointment or release. It is also his duty to reorganize the subcommittees without delay. However, in the Association year in which his term as chairman expires, he should call on his successor for advice and assistance in this regard.

Subcommittees

In general, the committees are organized to conduct their work by the appointment of one subcommittee for each subject assignment. If deemed advisable, any subject may be subdivided into several parts and a separate subcommittee assigned to each part. Committees may find it of advantage to create a subcommittee on personnel.

Subcommittee chairmen should make a report on the status of their work at each committee meeting. If they cannot be present at any meeting, they should submit such report to the chairman in writing, to be read to the meeting, or should arrange for some member of their subcommittee, or of the AAR research staff to report for the subcommittee. This rule should be followed even though the subcommittee has little or nothing to report at any particular meeting.

Organization Charts

The chairman shall furnish the executive secretary of the Association two copies of the organization chart (schedule of subcommittee assignments and personnel) of his committee, and shall advise him currently of any subsequent revisions thereof. This chart may be in the form regularly used by committees, but should not be in the form of a blueprint, on which it is difficult to make corrections. White prints are acceptable. These charts should be in the hands of the executive secretary by February 1, and should be prepared with the greatest care to insure the accuracy of initials and names.

The names of "guest" members on committees, if any, (not "visitors") should appear on the charts, but should be clearly designated as such. These names may be arranged either alphabetically among the members or grouped at the bottom of the chart as desired by the various committees. Names of "visitors" should not appear on or be subsequently added to these charts. Charts should also list (a) names of all committee members who are collaborators with other AREA committees, and (b) separately, the names of all non-members of the committee who are collaborators from other AREA committees and other organizations.

Handbook for Committee Chairmen

For the assistance and guidance of committee chairmen in the conduct of their committee work, the Association has published a small mimeographed "Handbook for Committee Chairmen", which contains the following material:

Procedures that Can Be Adopted by Committee Chairmen to Stimulate the Most Effective Committee Work.

Procedures Designed to Expedite the Conduct of Committee Meetings, Stimulate Greater Interest in Them, and Produce the Most Effective Results.

Report of a Well Conducted Committee Meeting.

Copies of this handbook are available to committee chairmen from the executive secretary's office.

Voting in Committees

Voting in committees and subcommittees on all Association matters shall be the prerogative of active Members only, except that retired Members, Associates, and Juniors may vote on matters of a social nature or on ballots for Member Emeritus of the committee.

COMMITTEE AND SUBCOMMITTEE MEETINGS

Location and Number

Most committees find it possible to conduct their work effectively with a maximum of three meetings each year. While these meetings can be held at any time to fit in best with the work of each committee, the trend in recent years has been for committees to hold their first (organization) meeting each year in January or February in order to get an early start on their new year's work, and not wait until after the annual convention in March. However, concurrent or overlapping committee meetings are undesirable from the standpoint that they may draw several key personnel from the same railroad at the same time, or otherwise adversely affect the attendance at the committee meeting. Accordingly, before committees decide definitely on meeting dates and send out notices thereof, they should clear these dates with the secretary's office.

Subcommittee meetings can likewise be held whenever desired, either independent of full committee meetings or in conjunction therewith. The latter plan has the advantage of minimizing travel time and possibly total time away from members' offices. Where subcommittee meetings are held in conjunction with general committee meetings, they may be held immediately before or after such meetings, or during such meetings if desirable, in recesses specifically called by the committee chairman for this purpose.

Committee meetings or subcommittee meetings should be held at points most convenient to the majority of members in order to hold down traveling time and expense, except that meetings may be held elsewhere to permit inspections important to the work of the committee or subcommittee. The Association has no funds to defray the cost of meeting rooms. Therefore, committees should hold meetings where no charge is made for such rooms, or to work out some other arrangement agreeable to members of the committee.*

Notices and Minutes

Committee chairmen shall send out, or arrange to have sent out, well in advance of meetings, copies of notices of all committee meetings to both committee members and collaborators. Two copies of all such notices should be sent to the secretary's office as early as possible for publication of meeting dates and places in the AREA News. In this latter regard, and especially if mailing of official notices is to be delayed, chairmen should give the secretary's office advance information about meetings, if possible. It should be kept in mind that the deadline for material for any issue of the News is the twentieth day of the month immediately preceding the date of issue.

Meeting notices, generally, should include or be accompanied by an agenda, preferably in timetable order, for the benefit of any members who may not be able to be in

* Conference Room 1218 at AREA headquarters in Chicago, which will accommodate up to 30 people, is available for committee and subcommittee meetings to the extent that it has not already been committed for other use. The Conference Room at the AAR Research Center, 3140 South Federal Street, Chicago, which will accommodate up to 50, is also available for committee meetings. Arrangements for the use of Room 1218 should be made through the secretary's office. For use of the Conference Room at the Research Center, arrangements should be made through the office of G. M. Magee, director of engineering research, at the Research Center.

attendance the full time of any meeting. They should also include as much information as possible relative to any inspection trips or other features planned.

Minutes of all committee meetings should be prepared as soon as possible following meetings, and copies should be sent to all committee members and collaborators—with two copies to the secretary's office.

Reporting on Inspection Trips

In order that highlights of all committee inspection trips may be published in the News, committee chairmen should send detailed information concerning such trips to the secretary's office, or arrange to have such information sent, as soon as possible after the completion of such trips, keeping in mind that the deadline for news to appear in any issue of the News is the twentieth day of the month preceding the date of issue.

Included among details furnished should be the name of the host or hosts (companies or company representatives) on the occasion, the facilities or operations observed, and separately, the number of members and guests who participated.

COLLABORATION

Between AREA Committees and with AAR Committees

Subjects, the nature of which clearly indicates the possibility of overlapping interest of two or more AREA committees, or the interest of committees of other groups with which the Association has agreed to collaborate, carry an appended clause reading: "collaborating with ....." It is the duty of the chairmen of subcommittees having an assignment carrying this instruction to take the initiative in effecting such collaboration—by arranging for the appointment of a representative of the other interested group, should such be mutually decided as desirable, or by setting up an arrangement whereby the collaborating group will review and criticize any reports submitted to it. If a representative or collaborator is appointed, he should be kept fully advised of all activity of the subcommittee involved. Regardless of whether the assignment specifically mentions collaboration, committees should be on the alert to obtain the advice and assistance of other AREA committees or interested groups in dealing with any subject that imposes any questions of possible overlapping interest or responsibility.

The reports of subcommittees involving collaboration should be submitted to collaborators or collaborating groups whether they are for information only or involve specifications or recommended practice, and should be submitted as far in advance of filing date as possible. If they cannot be submitted prior to the committee's filing date for any reason, they should be submitted as soon thereafter as possible, and in any event prior to the annual meeting, so that if the collaborators, or the groups they represent, desire to comment thereon or to take exception thereto in any respect, such can be done in writing to the committee chairman or subcommittee chairman involved prior to the annual meeting, or in written or oral form at the annual meeting.

A committee undertaking revision of its Manual chapter should request collaboration of any committee that participated in the original development and adoption of the material under revision. The executive secretary of the Association will provide information concerning such previous collaboration.

If an AREA committee or subcommittee is asked to collaborate with another AREA committee, or with committees of any of the sections or divisions of the AAR, it shall appoint a representative to implement this collaboration, if such is mutually decided as

desirable, or it should agree, without a specific collaborator, to review and criticize any reports submitted to it. Committee members appointed to collaborate with any other AREA or AAR committees should report currently to their own committees on any matters of interest resulting from the collaboration.

The names of all collaborators, whether to or from a committee, should be shown separately on the committee's organization chart, as set forth under "Organization Chart."

With Other Organizations

Many AREA committees appoint from their membership representatives to serve as collaborators on committees of the American Standards Association, the American Society for Testing Materials, the American Concrete Institute, or other outside organizations, these representatives acting either directly for the AREA committees or in behalf of the Association of American Railroads which may hold membership in the organizations involved. In all such cases, representation in these other organizations, either initially or otherwise, is handled through the AREA executive secretary's office. Thus AREA committee nominations for representatives on these outside committees, or for changes in representatives, are made through the executive secretary's office, which transmits the nominations to the organizations, secures their acceptance, notifies those interested, and makes official record thereof.

Beyond this point the representatives carry on their collaboration independent of the executive secretary's office, but each AREA committee should keep on its organization chart a record of all of the organizations with which it collaborates, and the names of its collaborators, as set forth under "Organization Chart".

Committee members appointed to collaborate with other organizations should report currently to their own committees on any matters of interest resulting from the collaboration.

WORK OF THE COMMITTEES

Objectives

The objectives of the Association are advanced through the work of the committees in two ways—(1) the development of useful information pertinent to their assignments to be presented to the Association "as information," and (2) the formulation of recommended practices to be submitted for adoption and publication in the Manual.

Planning the Work

In pursuing the work on any assignment, the first step is necessarily one of fact finding, including (a) a study of available literature on the subject, particularly reports of previous investigations, (b) a compilation of current practice, especially recent changes in practice, and (c) resort to original tests or experimentation, after a canvass of all other sources of information indicates that research work is necessary.

Collection of Data

Committees are privileged to obtain data or information in any proper way. If desired, the executive secretary will *mail* circulars of inquiry, or questionnaires, prepared by committees. Where sufficient information can be secured from members of the committee, they alone should receive letters of inquiry or questionnaires. Where a broader

representation of railroads is necessary or desirable, such letters of inquiry or questionnaires may be sent to the appropriate officer within the engineering and maintenance of way departments of selected additional roads or of all AAR Member Roads.

Only in special cases should communications of any kind be sent to officers in other than the Engineering and Maintenance of Way Departments (presidents or chief executive officers, chief operating officers, chief mechanical officers, etc.), and then only over the signature of, or with the explicit permission of, the heads of the appropriate AAR department, division or section, such to be arranged for through the executive secretary's office.

Circulars of inquiry or questionnaires should be brief and concise; the questions contained therein should be specific and pertinent, and not of such general or involved character as to preclude the possibility of obtaining satisfactory and prompt response; should specify to whom answers are to be sent; and should be furnished in duplicate so that a copy can be retained by persons replying.

Research

It is primarily the responsibility of Subcommittee A of each committee to bring together recommendations for further study and research on the part of the committee, based upon suggestions received from other members of the Association, or as the result of its own observations within or without the railroad industry. Any recommendations for assignments in the following year which call for research appropriations should be processed with the committee early in the Association year, beginning with the close of the annual meeting in March, in order that any proposal for research approved by the committee, can be in the hands of the director of engineering research, AAR, with copy to the executive secretary, AREA, by July 1. These recommendations must be accompanied by a supporting statement setting forth: (a) the nature of the information sought; (b) how the railroads are adversely affected by the lack of this information; (c) the estimated cost of the investigation; (d) the estimated time to complete the work; (e) the basis for assuming that the investigation will produce the data desired; and (f) an estimate of the savings to be realized or other advantages to accrue from the successful completion of the investigation. A request for funds to continue or complete an investigation shall include also a statement of the results obtained to date.

Maintaining Manual Up to Date

Each committee shall critically review the material in its chapter of the Manual at such intervals as to insure that it is kept up to date. It shall resubmit all Manual material for revision or reapproval at intervals of not more than 10 years. This rule, however, is not intended to encourage the reapproval of documents only at 10-year intervals. On the contrary, and especially since each document in the Manual carries a reapproval line under its heading, committees are urged to recommend the reapproval of documents each time that revisions (major or minor) are proposed, using some such wording as "Reapprove with the following revisions". If such reapproval is not requested specifically when revisions are recommended, the document will continue to carry its previous adoption or reapproval line.

However, since two or more sheets must be issued in a Supplement every time a document is reapproved without revisions, to correct the document date and the contents page or pages, it is recommended that, in the interest of avoiding unnecessary printing

costs, documents which do not require revisions should not be offered for reapproval at intervals of less than 8 or 10 years.

Group Revisions in Specific Years

While it is a healthy situation for committees to be constantly on the alert to improve their respective documents in the Manual, and while some revisions in Manual material will be of a character that will require that they be made at the earliest possible date, many changes will be of an editorial or less important character and will not demand that they be made immediately.

Accordingly, in the interest of economy, committees should, so far as possible, group their revisions in any specific document, or anywhere in their respective chapters, looking to submitting them as a group at intervals of two or three years or more, rather than separately year after year—thus avoiding the necessity for reissuing the same Manual pages, including contents pages, in successive years, to the greatest extent possible.

NATURE AND PREPARATION OF REPORTS

Form of Report

It is important that committee reports be prepared in accordance with the following instructions pertaining thereto, and the Style Standards for committee reports, as detailed on following pages in this pamphlet.

At Least Brief Progress or Status Statements to Be Made on All Assignments

Committees should pursue their investigations on all assignments, but are expected to present detailed progress or final reports for publication only on assignments with respect to which pertinent information has been developed. However, with respect to all other assignments each year, the report of a committee shall include for each a brief statement as to the progress which has been made on it during the year, or in the event that no progress has been made, a brief statement as to the status of the project. These brief statements, which are intended to be informative to those interested in any specific subject in a year when no detailed report can be made, may be confined to as few as one or two sentences, which may be entirely adequate. In such cases, the statement should appear directly under the title of the assignment as listed in the chairman's introductory statement to the committee report as a whole, instead of the words used previously, "No report", or "Progress in study, but no report". On the other hand, if these "progress" or "status" statements, in order to be adequate to the situation, necessarily exceed 70 words, they should be presented in the usual manner as a subcommittee report, with assignment heading and subcommittee personnel. In such cases, the chairman's introductory statement should show, for the assignments in question, "Brief progress statement", and the page number, or "Brief status statement", and the page number, as the case may be.

Reports on Assignment A should not be submitted for publication.

Reports on Assignment A

In the case of Assignment A—Recommendations for further study and research, two reports on recommendations shall be made to the committee each year; (1) early in the

Association year with respect to any proposed new assignments involving appropriations for the conduct of research work, as set forth in detail under "Research", on page 17; and (2) late in the summer or early fall, covering recommendations with respect to new assignments for study which do not call for research appropriations. This latter report should also include recommendations as to whether any existing assignments can be, or should be, discontinued. Neither of the reports on Assignment A will be presented in the Bulletins of the Association, or orally at conventions.

Information Reports or Recommended Practice

Whether the report on any particular assignment should take the form of "information" or a "recommended practice," depends largely on the nature of the assignment. Some assignments will be fulfilled completely by the presentation of information; others call for information in support of appended recommendations that are submitted for adoption. In still other cases, the primary objective is a comprehensive statement of recommended practices, but the development of these recommended practices may entail investigation or research work, the results of which are of such importance as to warrant their presentation as information prior to the submission of the recommendations. In some cases, it may be advisable to submit material in the form of recommended practice, but as information only, with a view to inviting suggestions and criticism that may serve as the basis for revisions prior to the resubmission of the material for adoption at a later date. This, however, is not mandatory.

When the work has been completed on any assignment, the committee should request of the Board Committee on Assignments that the assignment be discontinued. Its last report on such an assignment should be designated as "final report" only when the committee does not contemplate further study of the subject in the near or foreseeable future; otherwise, the report should be designated as a "progress report", with the recommendation that the subject be discontinued until there are further developments.

Writing of Committee Reports*

Many progress or final reports, whether based on research or other investigation, best lend themselves to written presentation in orderly sequence or chronological arrangement, ending with any conclusions or recommendations which may have been arrived at. However, in most cases, and especially in the case of long reports, to conserve the time of members who may or may not be interested in the details of the study involved, it is recommended that reports be introduced with a brief highlight summary statement of the background, purpose and extent of the study, as may be desirable, and including a synopsis of any conclusions, recommendations or other results—this latter material to supplement a more detailed presentation elsewhere in the reports.

Reports of information, supplementing previous reports of progress, should make reference to the previous reports by Proceedings volumes, year and page number, and may include a brief review of material previously presented, but should avoid extended repetition of such material.

Use of Trade Names

Committee reports which are based upon physical research or field tests carried out by or through the research staff of the Engineering Division, AAR, may use trade names or manufacturers' names in referring to products, machines, devices or processes under test, in accordance with rules in effect with the AAR Engineering Division research staff.

* See also Style Standards for Committee Reports.

No other committee reports, however, shall contain the trade names of products, machines, devices or processes, nor the names of manufacturers, in either text or cut captions, unless in each instance approval is secured from the Board Committee on Publications prior to the publication of the reports. To seek such approval, a committee must submit five copies of the report in question to the executive secretary's office, for transmission to the members of the Board Committee, six weeks prior to the scheduled filing date of the report. If time does not permit a ruling upon the request of the committee prior to the publication date of the report in question, the report of the committee must either be altered to eliminate the trade names or terms involved, or be withdrawn, at the discretion of the committee which prepared it.

Trade or manufacturers' names are not to be used anywhere in the Manual of Recommended Practice, the Portfolio of Trackwork Plans, the Handbook of Instructions for Care and Operation of Maintenance of Way Equipment, or other comparable publications of the Association.

Illustrations in Committee Reports

Committees may use illustrations within their reports, both photographs and line drawings, to the extent necessary to enhance the value of their reports, or to preclude detailed descriptions or the presentation of detailed data which would otherwise be required. For the physical requirements of such illustrations, see "Illustrations" under Style Standards. No illustrations, within themselves, shall show trade or manufacturers' names; neither shall the captions for such illustrations use trade or manufacturers' names, without prior approval on the part of the Board Committee on Publications, as is set forth under "Use of Trade Names".

Nature of Manual Material*

The material adopted by the Association for publication in the Manual shall be considered Recommended Practice, but shall not be binding on the members. Recommended Practice, as defined by the Board of Direction (May 20, 1936) is a material, device, plan, specification or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view to promoting efficiency or economy, or both, in the location, construction, operation or maintenance of railways.

Printing of Manual Material*

Material offered for adoption and publication in the Manual, except as noted herein, should be submitted in full, regardless of its publication in previous years, unless the material in question appeared in substantially identical form not more than one year before being submitted for adoption. Such material shall appear in the report of the committee that is published not less than 30 days before the annual meeting at which it is to be presented. Recommended revisions of Manual material, if extensive, shall include only the proposed material, which shall be printed in full in the report of the committee. Manual material recommended for reapproval, or for deletion, shall be presented by title and page reference only. Likewise, plans, specifications or other documents of other organizations recommended for adoption by the AREA shall be presented by title and serial designation only, e.g., current ASTM specifications, designation D 17.

* Same applies to Portfolio of Trackwork Plans.

When entirely new material is offered for inclusion in the Manual, the committee sponsoring it should state specifically in its report the exact location the material is to have in the Manual.

Letter Ballot Required of Committee*

Any action recommended by a committee with respect to the adoption, revision, reapproval or withdrawal of Manual material must have received prior endorsement by the committee in the form of an affirmative vote of two-thirds of the voting membership of the committee, such vote to be taken by letter ballot. Associates, Junior members, Members Emeritus, and retired members on a committee are not entitled to vote. Thus, it is imperative that committee members promptly consider and vote on all letter ballots, seeking the advice of other committee members or specifically qualified officers on their own roads if in doubt as to whether to vote for or against a proposal.

If a member votes in the negative on any Manual proposal, it is encumbent upon him to state the reason or reasons therefor.

PUBLICATION OF REPORTS

Dates for Filing Complete Committee Reports

To insure the orderly publication of the reports in the four winter Bulletins of the Association—November–February, incl.—in accordance with a predetermined schedule, it is necessary that chairmen file complete reports with the executive secretary of the Association on or before the dates specified in the Committee Assignments for Study and Research pamphlet.

Reports to be published in the June–July and September–October issues of the Bulletin shall be submitted in the same manner by committee chairmen, or by members of the AAR research staff in their behalf, as other reports, on a schedule worked out with the secretary's office.

The manuscript of the report must be furnished in duplicate, preferably double spaced. Piecemeal filing of reports by subcommittee chairmen is permissible only under special arrangement (in writing) with the executive secretary of the Association.

The regular annual reports of committees—to appear in the winter Bulletins of the Association—must in each case include an introductory statement, or committee chairman's report, embodying the personnel and list of assignments of the committee, as set forth under Style Standards for Committee Reports, pages 25 to 27, incl.

Portrait Photographs of Committee Chairmen

During his first year as chairman, each chairman must furnish the secretary's office a portrait photograph of himself to be used with the reports of his committee as published in the Bulletins and Proceedings while he is chairman. If this has not been done prior to the filing of the committee's report, it must be done at that time. The photograph furnished need be of no special size, but should be black and white, clear, and an acceptable likeness of the chairman. These photographs will be returned to chairmen upon request.

* Same applies to Portfolio of Trackwork Plans.

PRESENTATION OF REPORTS AT ANNUAL MEETINGS

Presentation of Reports

Reports offered as information should be presented by title or by a brief highlight outline of the contents. Material submitted for adoption and publication in the Manual* may be presented by reading the title and subtitles, but the presiding officer may, upon request, authorize the reading of specific portions of the material being offered.

Since both the degree of effectiveness with which a report is received by those assembled in annual convention, and the accuracy with which it can be reported in the Proceedings, depend upon the clarity with which the oral presentation is made to the meeting, it is desirable that committee members write out and read their presentations, and that they speak directly and distinctly into the microphone at the rostrum, raising or lowering the microphone as may be necessary to that end. In the event that written presentations are read, a copy of such presentations should be given to the executive secretary or to the convention reporter before the speaker leaves the rostrum.

Visual Presentations

The use of illustrations in the form of slides, motion pictures, etc., as a part of or in conjunction with committee presentations, whether reports or special features, shall be governed by the following rule:

Films** produced by supply companies, manufacturers, and supply organizations depicting their products or services in any form are not to be used in connection with committee presentations, either supplementing committee reports or as special features, at annual meetings, and the use of trade association films is not encouraged. However, under special conditions, where a committee desires to use a trade association film in connection with its presentation, the matter must be referred to the Board Committee on Publications for approval, through the executive secretary's office, by January 1 of the year inquestion, in order that a ruling may be secured prior to the publication of the convention program in the AREA News. Trade association films to be considered under this rule must be of an educational, rather than of a sales-promotion type, must make no direct or indirect comparisons with other products or services, and may make reference to the associations which produced them in only an innocuous way.

Oral Discussions

Comments on or criticisms of any report may be offered from the floor. When necessary to insure accuracy, or upon request, the speaker's remarks will be submitted to him in writing before publication in the Proceedings, for the correction of diction, misstatements, and errors of reporting, but not for the elimination of remarks.

Written Discussions

Written discussions of published reports will be transmitted to the chairman of the interested committee who will read or present them by title or in abstract at the convention. Written discussions will be published in the Proceedings as a part of the discussion of the committee reports.

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* Same applies to Portfolio of Trackwork Plans.

** Wherever the word "film" is used, it applies as well to slides and any other form of visual presentation.

Action on Reports

No formal action is to be taken by the convention on material submitted as information, whether in the form of a progress or final report.

Action on material submitted for adoption and publication in the Manual will be one of the following:

(a) Adoption as a whole as presented.

(b) Affirmative action on the amendment of a part or parts of the material presented, followed by adoption as a whole as amended.

(c) Adoption of a part, complete in itself, and referring the remainder back to the committee for further consideration.

(d) Recommittal with or without instructions.

Note.—An amendment which affects underlying principles, if adopted, shall of itself constitute a recommittal of such part of the report as the committee considers affected.

The Chair will decline to entertain amendments which in his opinion are primarily a matter of editing.

MISCELLANEOUS

Memoirs

The Association has developed a complete set of rules with respect to memoirs in committee reports or elsewhere in its publications, covering the scope, preparation and presentation of such memoirs. Copy of these rules, as well as the Association service record of any deceased member, can be secured from the executive secretary's office.

Letter Ballot of Membership

When and as required between annual meetings, recommendations for the adoption, deletion, revision or reapproval of Manual material shall be submitted to letter ballot of the Members of the Association under the following limitations:

(a) That the letter ballot shall be taken only after the Board of Direction has recognized the necessity for such emergency action, and

(b) That the propositions submitted by the committee shall have the approval of a special committee of the Board of Direction appointed by the President for that purpose, both as to the substance of the material offered and also as to the circumstances attending the consideration of the material by the committee.

The Board of Direction, acting under the provisions of paragraphs 6 (a) and 11 of Article VII of the AREA constitution, has the authority to amend, delete or revise Manual material at any time, subject to later confirmation or rejection by the membership, submission to the membership to be effected either by means of a letter ballot immediately following such Board action, or by a motion presented at the annual meeting.

Review by Association of American Railroads*

All material adopted for publication in the Manual and all recommendations for the revision or withdrawal of Manual material shall be referred to the vice president, Opera-

* Same applies to Portfolio of Trackwork Plans.

tions and Maintenance Department, Association of American Railroads, for review, before distribution is made thereof to holders or purchasers of the Manual, or parts thereof.

Publication and Distribution of Annual Supplement to Manual*

Revisions of or additions to the Manual authorized by action at each convention will be published annually in the form of loose-leaf sheets which will be made available to all holders of the Manual. These supplemental sheets will be accompanied by instructions for insertion of the new sheets and the withdrawal of sheets that have been superseded, as well as those sheets that have been withdrawn by action of the Association.

In order that committee members who have purchased individual Chapters of the Manual in connection with their committee work may keep these separate Chapters up to date, the secretary's office will make available to them annually, through their committee chairmen, those supplement sheets required to this end.

Publication of Abstracts by Technical Journals

The following rules will govern the releasing of material for publication in technical journals:

Committee reports to be presented at an annual meeting will not be released for publication until after presentation to the annual meeting. Special articles, contributed by members and others, on which no action by the Association is necessary, will be released for publication in technical journals only after issuance in a Bulletin; provided, application therefor is made in writing and proper credit is given the Association, authors or committees presenting such material.

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* Same applies to Portfolio of Trackwork Plans.

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